JANUARY • 1955

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

What's New in
COMPRESSORS
See Page 117

"RETAINED VOLATILITY"
Seasons
YOUR MOTOR FUEL

Make certain your Motor Fuel loses none of its high quality before or after it gets into the customer's tank.

Blending with NATURAL GASOLINE will "season" your product with RETAINED VOLATILITY.

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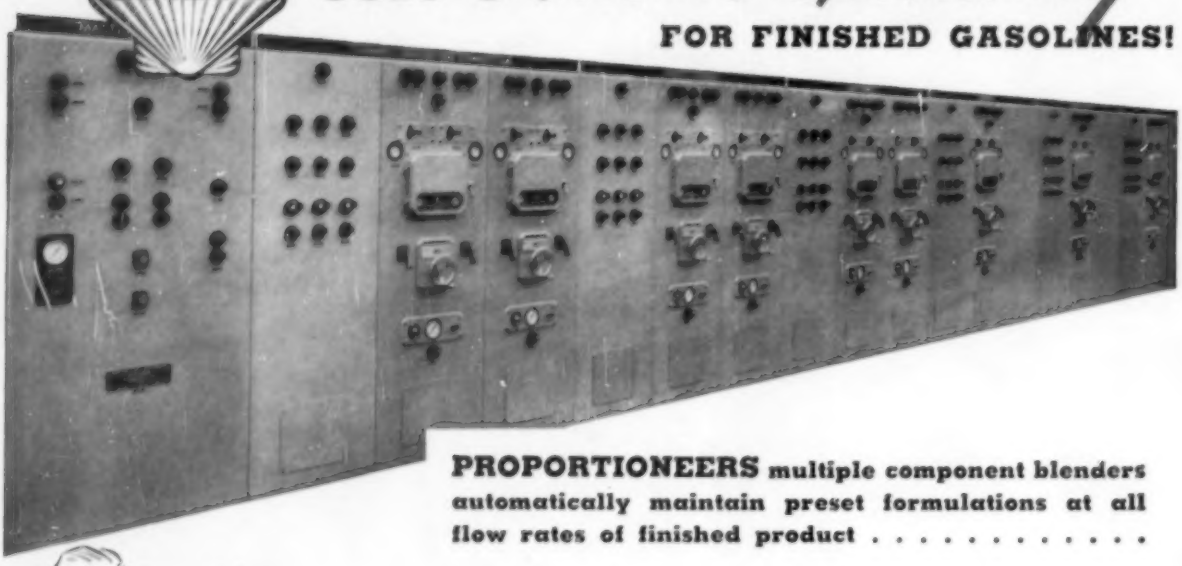
SHELL USES *Stream Blending* FOR FINISHED GASOLINES!



PROPORTIONEERS multiple component blenders automatically maintain preset formulations at all flow rates of finished product . . . . . .

SEE "STREAM BLENDING" AT WORK

A new Shell-Proportioneers film graphically illustrates the Wood River blending installation together with calibration and product separation techniques employed. We will gladly loan this film for educational use.

Shell Products Pipe Line's Wood River Pump Station automatically blends six gasoline base stocks, T.E.L., dye, and gasoline additives directly to the pipe line without using intermediate tankage.

Proportioneers Blender is made up of standard panels for operation from either mechanical or differential metering equipment. All control panels are synchronized and electrically interlocked so that the failure of any component stream will either isolate the blend manifold or rack up shortages on memory totalizers for later correction. Any number and type of components can be handled at finished product rates from 150 barrels per hour to the limit of modern transfer pumping equipment and pipe line sizes.

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For Proportioneers Bulletin SM-2060 or special bulletin for specific applications listed above, write Proportioneers, Inc., 412 Harris Avenue, Providence 1, Rhode Island.

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DIVISION OF B-I-F INDUSTRIES, INC.

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BIF METERS FEEDERS CONTROLS

TECHNICAL SERVICE REPRESENTATIVES IN PRINCIPAL CITIES IN THE UNITED STATES, CANADA, MEXICO AND OTHER FOREIGN COUNTRIES

Volume 34, No. 1 January, 1955

PETROLEUM REFINER
REFINING | PETROCHEMICALS | NATURAL GASOLINE

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A Quick Look at This Issue

Busy oil men can put first things first by scanning Quick Look's handy digests and checking ✓ those they want to read first

☐ **What's Ahead In 1955?** . . . Will 1955 be as good a year as 1954 for the petroleum industry? What's going to be the demand for refined products in United States? Is the rest of the world going to follow the same trend? What's all this talk about a plateau in demand for liquefied petroleum gases? These are some of the questions we sought to answer in this symposium of five articles devoted to a review of last year and a forecast of the new year.

☐ **Industry Leaders Predict Good Year** . . . All signs point to a good new year according to these twelve industry executives. Big problems include the new decision on federal regulation of natural gas and the age-old problem of keeping supply in balance with demand. Several refiner executives see big process advances as the most important development in 1955. **Page 98.**

☐ **U. S. Demand to Increase 4.3 Percent** . . . Demand for U. S. refined products will closely follow the general growth of the nation's economy, according to our calculations. Question marks should be placed on what type of winter the country experiences and how much inventory adjustment refiners make in the coming months. We can say for sure, though, that jet fuel will take the biggest jump in demand as the military has a pretty firm program (barring all-out war, of course). **Page 104.**

☐ **Taking Stock** . . . This regular department shows that inventory of stocks during 1954 have been worked down to an optimistic level except for gasoline. Certainly, there'll be no trouble meeting demand with these ample stock supplies. **Page 106.**

☐ **World Demand Expands Faster** . . . Product demand outside the U. S. will again expand faster than the U. S. The rate will probably be about 8 percent. The previous year saw a 9.5 percent increase in demand. There's some oversupply in the

→ Turn the Page →

world market and this factor added to the return of Iranian production may mean a greater degree of price shading than in 1954. **Page 107.**

☐ **LPG Demand to Climb** . . . Phenominal gains in previous years won't be equaled but increase in 1955 should be as good as 1954. LPG has many outlets as you will see in this article which analyzes the year 1954 according to LPG uses. **Page 108.**

☐ **Centrifugal Compressor Symposium** . . . As one of the newest trends in refinery and petrochemical equipment, the centrifugal compressor has become a part of every modern refinery. The centrifugal compressor offers the advantages of a wide operating capacity range and low maintenance. It has found wide acceptance in the medium capacity range. There are many considerations which go into selecting a compressor so we've covered all phases of this development in a seven-article symposium:

- **Introduction and Principles** by W. O. Lowell, **Page 118.**
- **Theory of Operation** by H. A. Erb, **Page 123.**
- **Important Performance Characteristics** by T. P. Latimer, **Page 130.**
- **Process and Mechanical Design** by Clark Shields, **Page 132.**
- **Specification and Selection** by Orin A. Smith, **Page 136.**
- **Operation and Maintenance** by Sherman L. Cole and G. D. Peet, **Page 140.**
- **Seals and Sealing Systems** by Donald F. Crego, **Page 143.**

☐ **How To Test Fractionators—Part 1** . . . Beginning a most interesting and valuable two-part series on how to get the most out of distillation equipment. The authors describe with meticulous care methods for analyzing the performance of your present distillation equipment, and means for insuring that you operate at the money making optimum. Part 1 describes the evaluation of precise fractionators, while the second part deals with crude fractionators. **Page 110.**

☐ **How To Desulfurize Diesel Fuel** . . . New catalytic desulfurization processes are giving solvent extraction routes a run for their money. In this article you'll find a thorough survey of all processes available and an economic comparison between the types. **Page 115.**

☐ **Making Aldehydes from Petroleum, Part 1** . . . The versality of the aliphatic aldehydes has been the driving force behind the development of new and better processes for their production from petroleum. Here is the first of a three-part series tracing the routes by which they are made. For a complete picture of this segment of the petrochemical industry, turn to **Page 147.**

☐ **Fractionation Research Starts Era** . . . Forty-three companies are cooperating in a new phase of research to find the effect of tray design, system properties and operating conditions on capacity and tray design efficiency. **Page 154.**

☐ **Why Electronic Process Control?** . . . Lately considerable attention has been given to electronic controllers for processing units. Although there has been much talk about the electronic unit being faster, it's actually slower than a modern force balanced controller mounted directly on the valve. However, there are far more important reasons for using this type of control as you'll find out in this article. **Page 155.**

☐ **The Economics of Heat Exchanger Design** . . . Here is a comprehensive set of data on heat exchanger estimating. The authors provide data on the three basic types of heat exchangers and actual cost data for each type. Included also is the influence on cost of items such as tube size and pitch, and variations in tube material and design pressure. Project and process engineers will find these curves to be valuable data. **Page 159.**

☐ **Canning Device Breaks Bottleneck** . . . Here's a can "unscrambler" which Shell Oil Company has found reduces a major bottleneck at its Sewaren, N. J., plant. Empty oil cans speed through the juncture of chutes inbound from two railroad cars by means of a rotating turntable. **Page 164.**

☐ **Is Poor Health Really the Price of Success?** . . . No, declares the author in contradiction of the findings of many medical authorities. The incidence of stress diseases was studied in about 700 senior and junior executives at du Pont. The findings are highly gratifying to hard-driving executives who have been led to believe that poor health is the price of success. **Page 211.**

☐ **Tailor Your Training Program** . . . The approach to executive training depends on the particular needs of a company. Here are 27 techniques that will help you to develop managers. **Page 222.**

☐ **Now Try the Dynamic Merit Increase** . . . Are you dissatisfied with the employe incentive your dollars have bought? Perhaps you have tried profit-sharing and production bonuses and found them lacking. Perhaps you are clinging to the ancient practice of "tips for tenure"—rewarding employes for coming to work every day. If you feel the need for a better program, here is a plan for rewarding real merit. **Page 228.**

PETROLEUM
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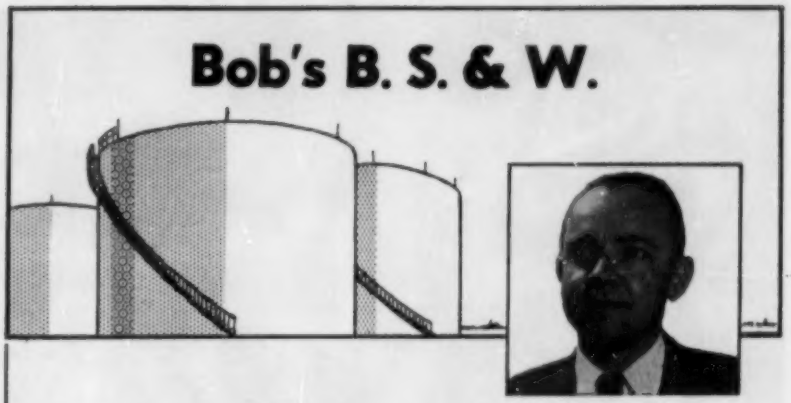
Bob's B. S. & W.



You will be relieved to know that you can still call petrochemicals by that name, although the ACS nomenclature committee won't think much of it. You may recall that a recent item in this column announced the meeting of the committee to determine just how good a word "petrochemicals" is. We've just received a copy of the minutes of the meeting, and let me tell you, we certainly missed out by not being there ourselves and presenting a few briefs in the interest of the Defense. Quoting: "Drs. Fleischer and Ingerson presented the case for restricting use of the term to the etymologically correct use in connection with rock chemistry." The defense rested on one mighty sound thesis, ". . . company executives like it. They do not care where it came from and will continue to use it." Just put us in the same basket as those unfeeling company executives.

Swan Song

This is the last and final time I'll grind out a B. S. & W. column. Come January 1, I'll be engineering and peddling electrical treaters for the Howe-Baker Corporation, as manager of their treating division.

There's a lot of fun in store for the engineer who turns journalist and edits a technical magazine. The first dividend he receives is the opportunity to get around and see how the other fellow does it. Most of us with refining backgrounds seem to tend toward being inbred as far as ways of doing things are concerned. It comes as quite a shock to find out that other companies know how to do things too—sometimes even better! (I still will never admit that I found anywhere a group of engineers faster on their feet than they were at my old outfit.)

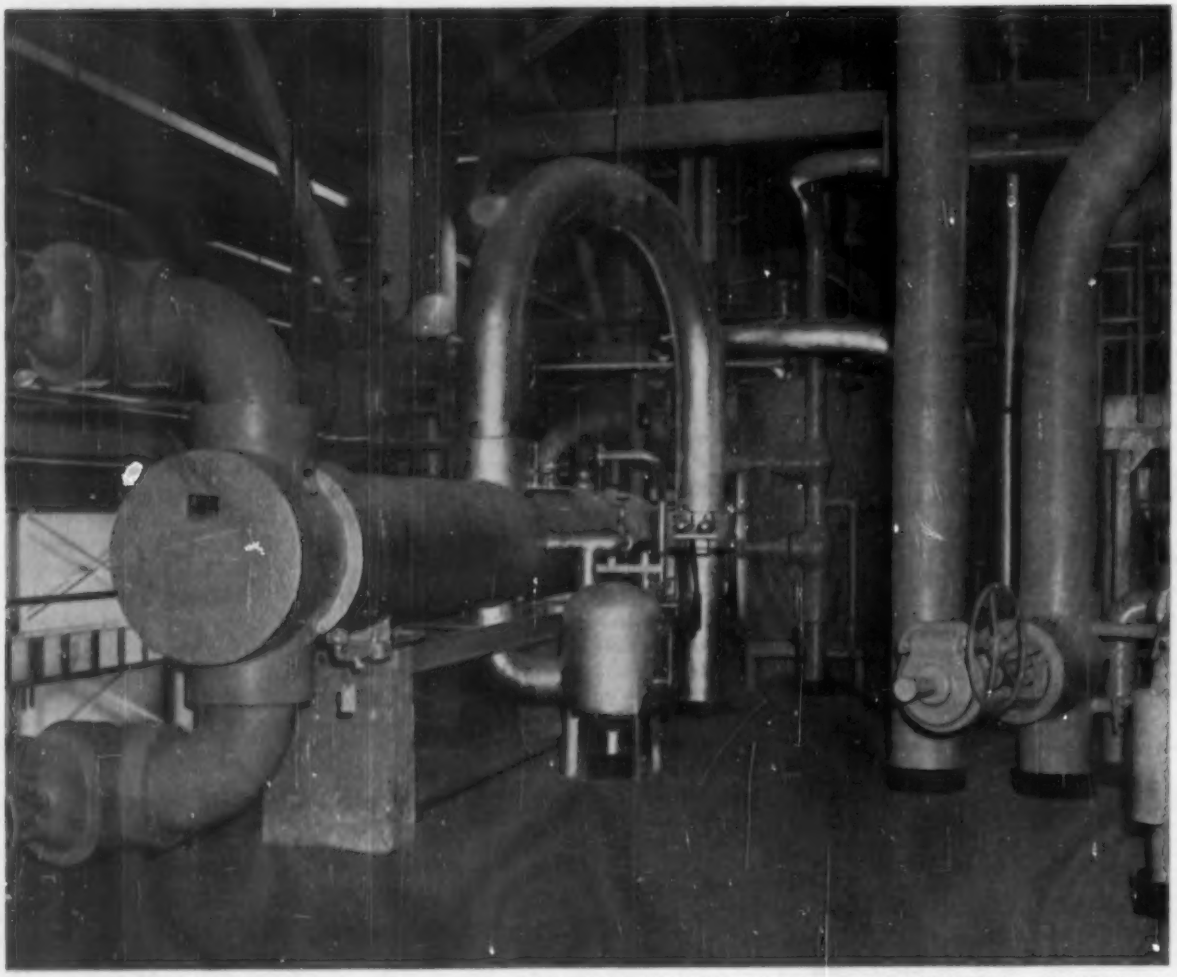
Technical editing, at least on a short time basis, is a fine technical education. The editor reads heaps more than he ever did, even in college, and even if only a small fraction of the technical material he digests sticks with him, he is far better off for the experience.

And the most fun of all is the opportunity to meet and visit with a great many people from all types of endeavor. One learns that most equipment manufacturers are sincere people who realize that in the long pull, their success depends on being of real help to their customers.

And now for a final word about PETROLEUM REFINER. It has been tremendously successful, particularly so in the last few years. Circulation gains have been fantastic, as has reader acceptance. I believe this is directly traceable to the sincerity and enthusiasm of **Ray L. Dudley,** the publisher. He sets policies on one fundamental belief, **"Nothing is too good for the readers."** He really believes this himself, and he makes editors who work for him believe it. Such devotion has paid rich rewards in satisfying contributions to the welfare of the industry.

Well, thanks for all your fine help these last few years. It has been mighty nice knowing you, and I'll be seeing you around.

—Bob Phillips



This evaporator-condenser unit in a modern power plant is insulated with "Featherweight" 85% Magnesia.

"Featherweight" 85% Magnesia insulation conserves heat and dollars

"Featherweight" 85% Magnesia (85% basic carbonate of magnesia and asbestos fiber) effectively insulates piping and equipment with temperatures up to 600° F. Used with a primary layer of K&M Hy-Temp Insulation (Diatomaceous Silica), the combination is effective up to 1900° F. The application of these two layers—with staggered joints—eliminates the heat loss that normally occurs when expansion causes the joints to open in single layer installations.

These K&M insulations last the life of the equipment they serve. They withstand moisture, vibration and frequent temperature changes.

New and now available is "Featherweight" Water-Resistant Magnesia Insulation for temperatures up to 450° F. It is used underground where severe water exposure may damage the insulation or on indoor steam heated lines and equipment where high humidity and moisture are present.

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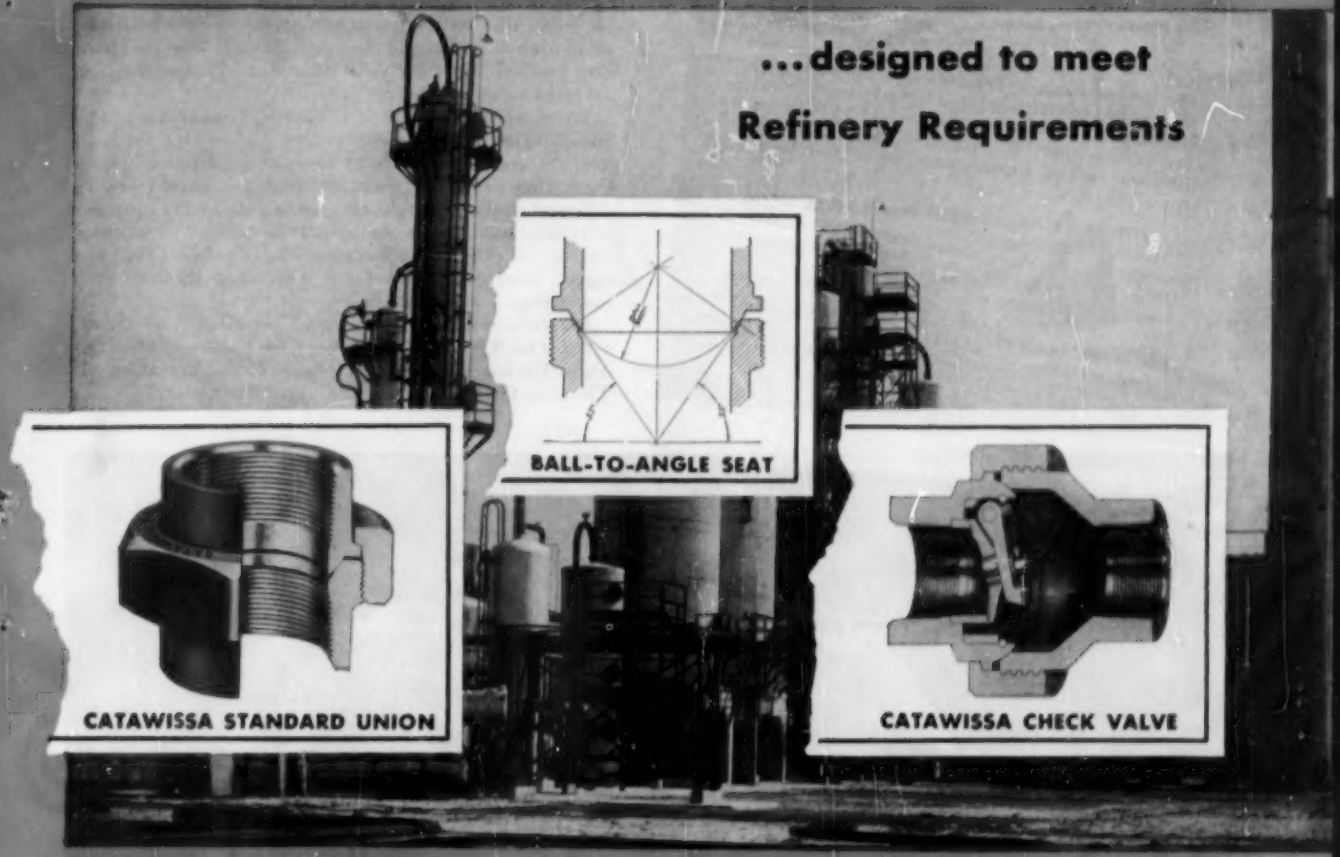

"OILWELL'S" strategically located refinery stock points carry complete lines of Catawissa forged-steel unions and check valves that meet the most severe refinery specifications.

CHECK THESE FEATURES

HOT-FORGED . . . from solid, rectangular steel bars, Catawissa Unions are free from sand and blow holes. They will expand and contract with the pipe, assuring tight joints.

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SEATS . . . in all Catawissa Unions are a 55° angle on the female end to a BALL on the male end, assuring a perfect seal even when the pipe is not perfectly aligned. Carefully hand-ground seats which require no packing are inspected and tested under water to assure holding qualities.

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UNITED STATES STEEL

The best way to get the most for your tube steel dollar: *Ask the experts!*

This month's report is on: **2% CR.-MO.**

Has intermediate corrosion resistance in combination with good creep strength and fair resistance to oxidation. For use at temperatures up to 1200°F. in cracking coils, reforming units, heat exchangers, vapor line and hot oil piping, and return-bend forgings for oil heaters.

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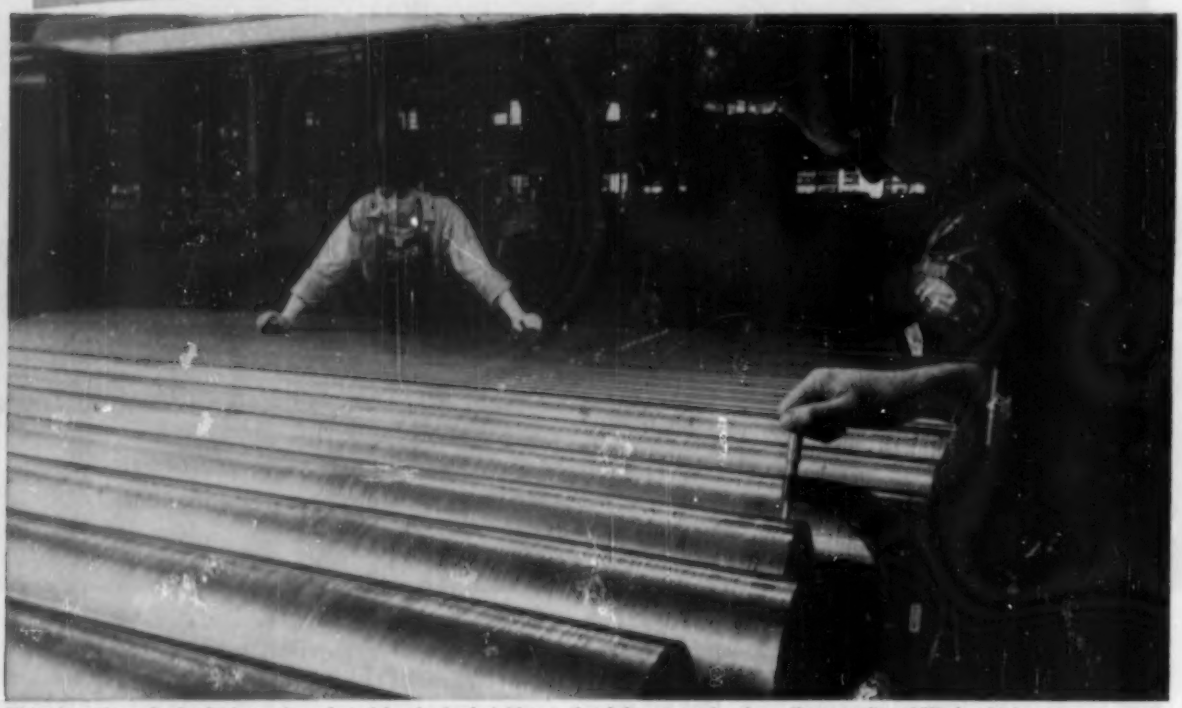
Carbon	Sicromo 2	Sicromo 9S	18-8Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-20
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

*Available as seamless tubing on an experimental basis only.
**Not available as seamless tubing.

THERE are probably several high temperature tube steels that will solve your heat, pressure, corrosion or oxidation problems. But there's only one that will give you the most for your tube steel dollar—the best life/cost ratio.

The best way to find it is to ask Timken Company metallurgists. They're recognized authorities on high temperature steels. With 23 years of experience behind them, they can help you select your best steel from 24 different analyses. You'll be sure of getting the most for your tube steel dollar. And you'll be assured of uniform quality in every tube because The Timken Company rigidly controls quality from melt shop through final inspection.

For help with your tube steel problems, *ask the experts!* The Timken Roller Bearing Company, Steel & Tube Division, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

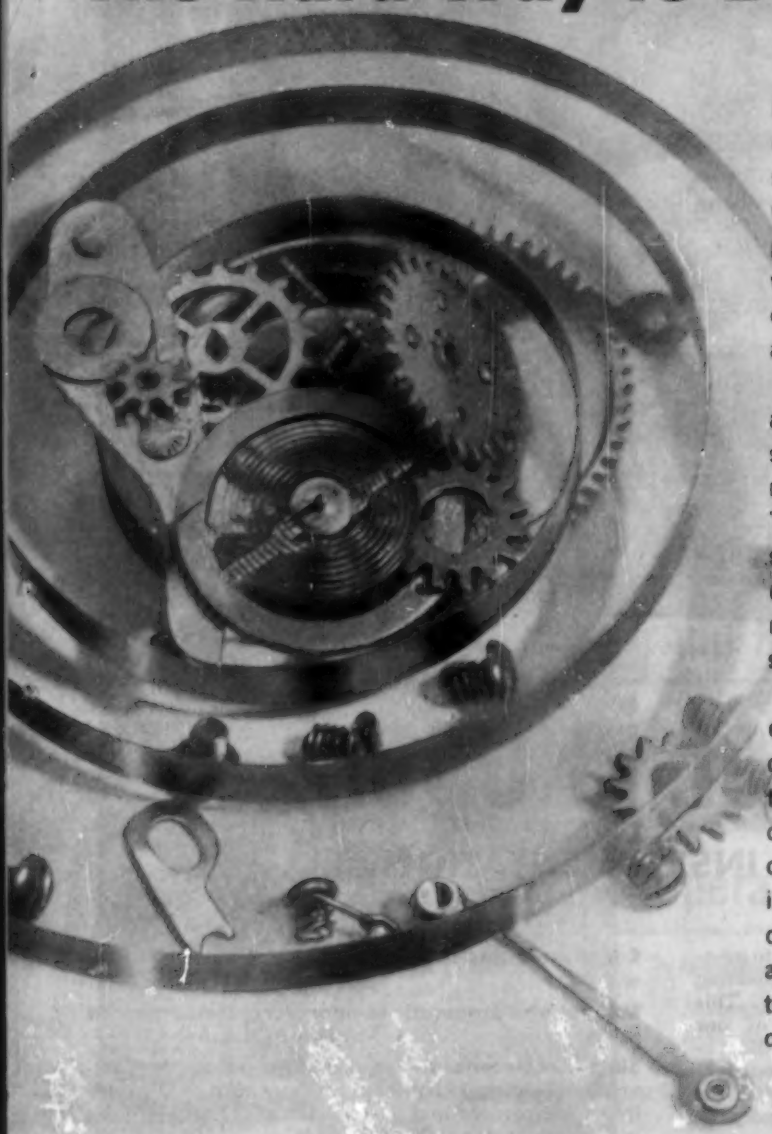


This photo shows final tube inspection—last of hundreds of rigid tests that help account for the uniform quality of Timken high temperature steels.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

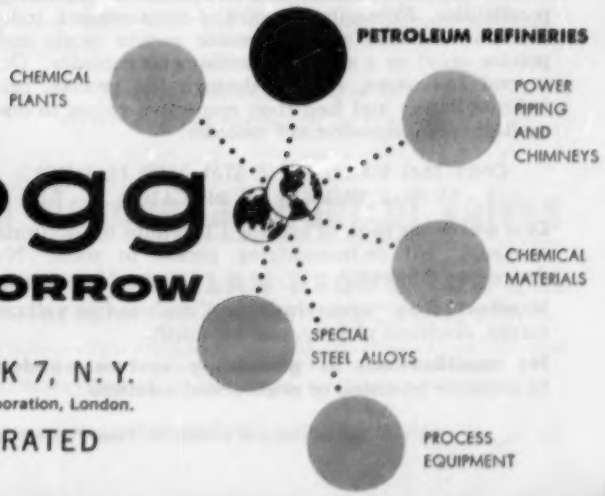
The Hard Way to Buy a Refinery



Buying a petroleum refinery in "pieces" from different sources, each with its own design standards and materials specifications, is somewhat like buying a watch the same way. An expert can put the units together and make them work. But it's a lot simpler, and usually more economical, to buy the complete "package"—assembled and already running when you get it.

When planning a new refinery, or modernizing an existing one, there are many economic reasons why it pays to have a single contractor responsible for integration of the entire project. These include centralized purchasing power; shorter and flexible construction schedules; uniformity of design factors in process equipment; and the elimination of duplicate construction managers and their staffs.

The M. W. Kellogg Company, world's leading designer and builder of petroleum refineries, offers a complete "packaged-plant" contract to the petroleum and petro-chemical industries. It covers process engineering; plant design and construction of the entire job, including off-site installations such as tanks, loading facilities, docks, roads; supervision until on stream; and a production guarantee. We welcome the opportunity to discuss with you the many advantages of The M. W. Kellogg "packaged-plant" contract.



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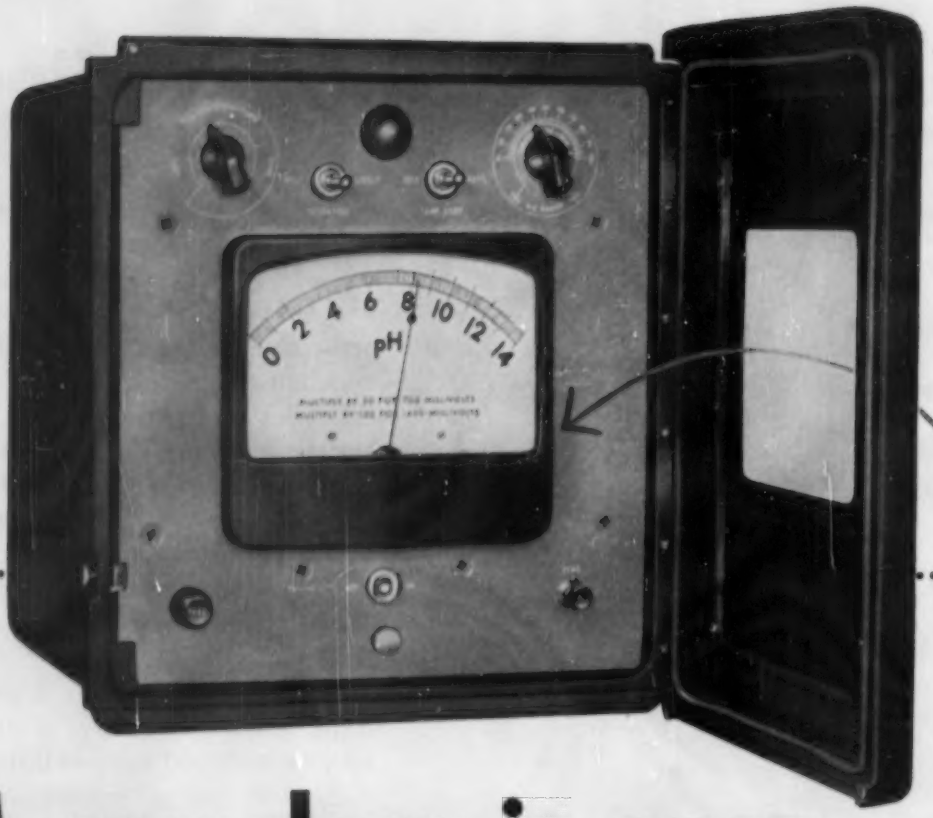

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Low warm-up time of less than 1 minute for accurate readings. No de-humidifying period to wait. No desiccants required.

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Completely enclosed case keeps out water or corrosive fumes.

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0 to 14 pH range in 0.1 pH div. 0 to 700 mv. in 5 mv. div., and 0 to 1400 mv. in 10 mv. div.

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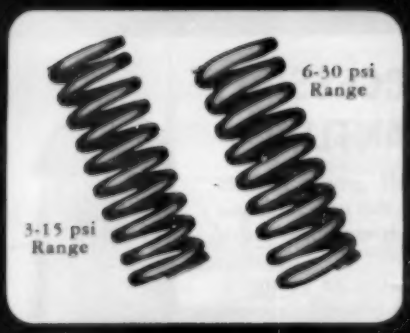
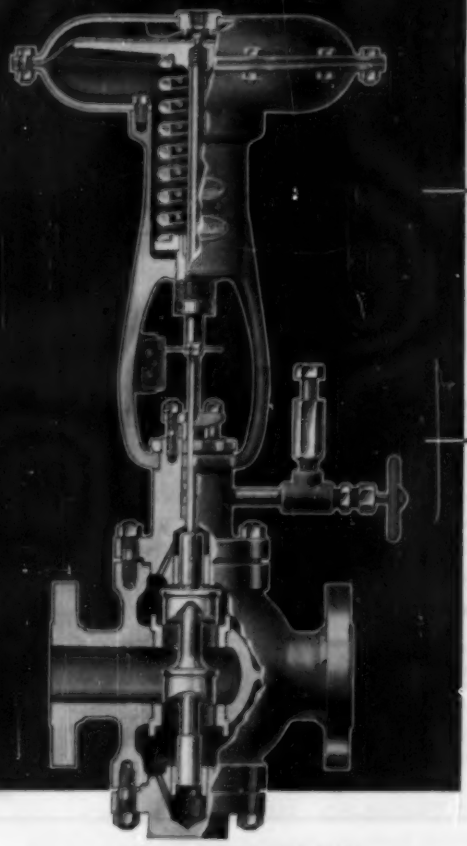
SPRING RANGE





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Doubles the power to operate the valve when conditions make it desirable or necessary.

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Provides large operating force at beginning of stroke.

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because

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Masoneilan Boosters (1 to 2 input-to-output ratio) may be used with 3-15 psi output instruments without positioner.

More details on the uses of this versatile spring range sent on request.

ALL HIGH Quality Efficient Co PRODUCTS

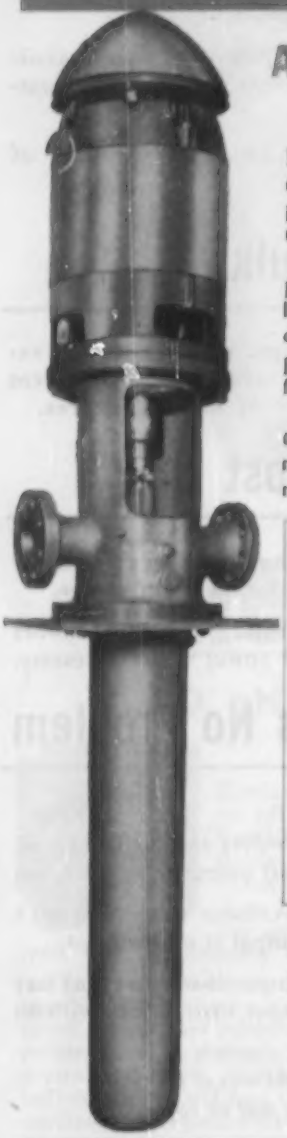
. . . in Masoneilan Control Valves

MASON-NEILAN REGULATOR CO.
1182 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis • Tulsa • Philadelphia • Houston • Pittsburgh • Atlanta • Cleveland Cincinnati • Detroit • San Francisco • Boise • Louisville • Salt Lake City • El Paso • Albuquerque • Odessa • Charlotte • Los Angeles Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

For more data on advertised products, use Readers' Service Cards, last page.

NEW! Bingham VCP VERTICAL PUMP FOR LOW NPSH



ALL WORKING PARTS ACCESSIBLE WITH BOTTOM DISMANTLING

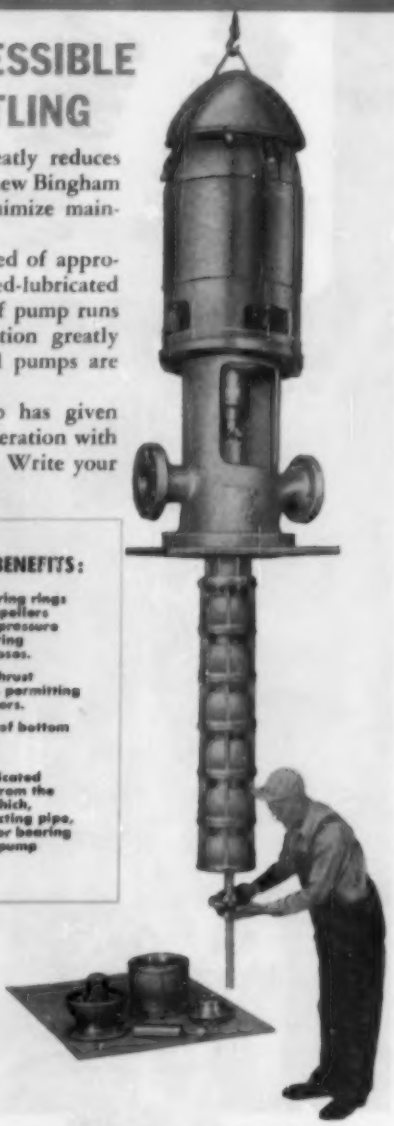
Besides bottom dismantling, which in itself greatly reduces maintenance time when attention is required, this new Bingham pump incorporates advanced features which minimize maintenance, reducing need for periodic inspection.

For example, all intermediate bearings (supplied of appropriate material for different pumpages) are forced-lubricated by pumpage. Bottom bearing is lubricated, even if pump runs dry for short periods. This *dependable* lubrication greatly prolongs life of bearings, which in conventional pumps are frequently the cause of maintenance shutdowns.

Wherever installed, the Bingham VCP Pump has given trouble-free service—plus unsurpassed smooth operation with no vibration. Available for any capacity or head. Write your nearest Bingham office for additional information.

ONLY Bingham OFFERS ALL THESE BENEFITS:

1. Heavy-duty steel suction and discharge head rigidly built to eliminate vibration caused by drivers.
2. Shaft is maximum diameter throughout.
3. Shafts are equipped with renewable 11-13 chrome, hardened, ground and polished sleeves at each bearing.
4. Bearings are of the appropriate material for the different pumpages.
5. Maximum head per stage and maximum efficiency for a given capacity range.
6. Front and back wearing rings on enclosed type impellers permit a one-stage pressure drop over each bearing for lubrication purposes.
7. Wear rings reduce thrust of rotating element, permitting use of standard motors.
8. Maximum eye area of bottom impeller for lowest possible NPSH.
9. Bottom bearing lubricated by pumpage taken from the discharge column, which, together with connecting pipe, acts as a reservoir for bearing lubrication in event pump operates "dry" for short periods.



All working parts of pump easily accessible with bottom dismantling. One man can service after lifting pump from well. By dismantling from bottom, repair or replacement of any part can be made in much less time than with conventional pumps (where dismantling begins from top, necessitating removal of driver and head before pump unit is accessible).

Various operators estimate that time required to reach working parts has been reduced as much as 50%.

Bingham PUMPS
SINCE 1921
DOUBLE VOLUTE RADIAL BALANCED

BINGHAM PUMP COMPANY
General Offices: 2800 N.W. Front Avenue, Portland 10, Oregon
Factories: Portland, Ore. • Vancouver, B.C., Canada

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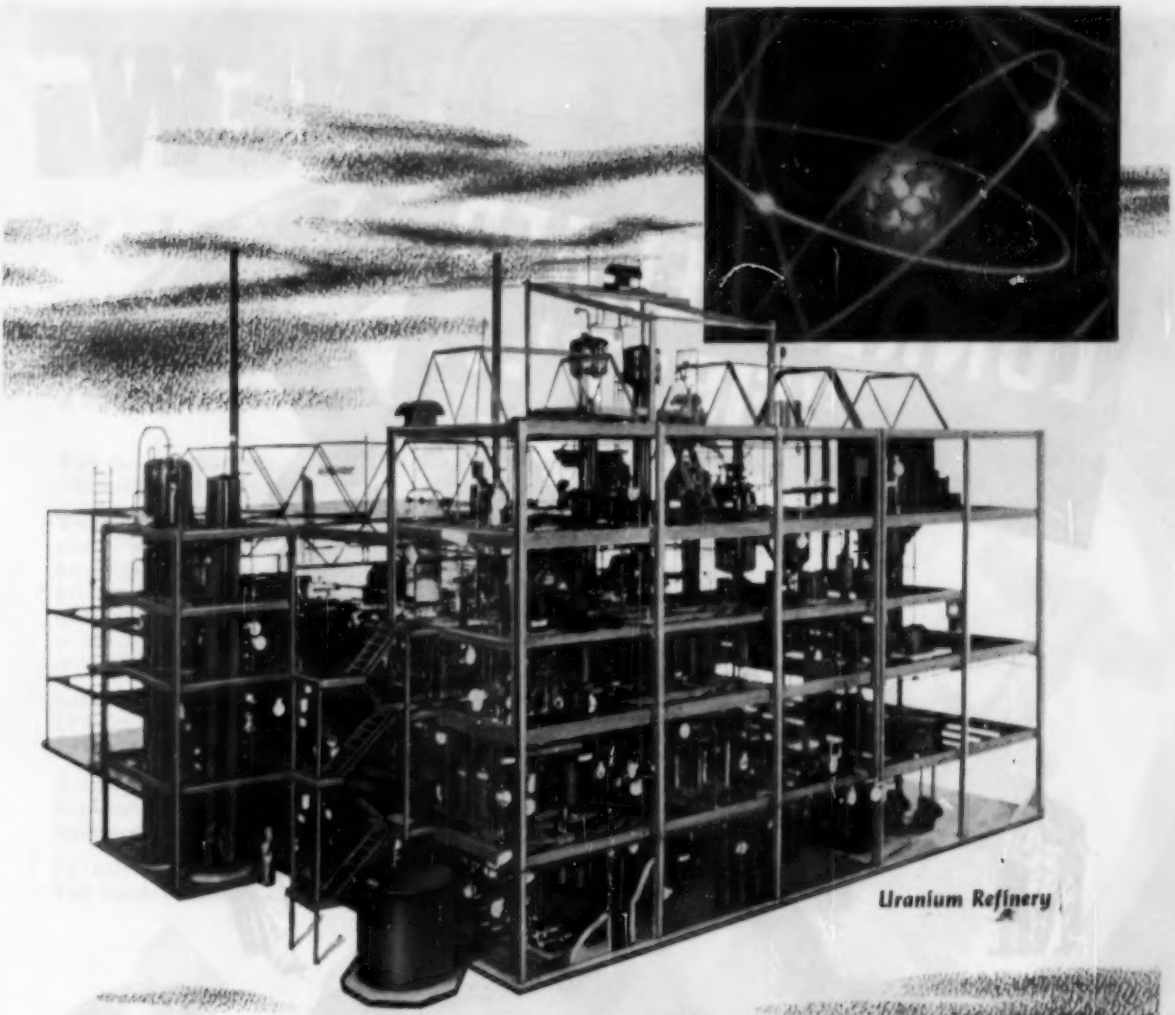

Uranium Refinery

MODEL for Tomorrow

The full scale commercial uranium refining plant—of which this is a model—is now under construction at Port Hope, Ontario, and will be completed in 1955, the first of its kind in Canada. With engineering and construction by Catalytic, it will make available to Eldorado Mining and Refining, Limited (a Crown Company) the most advanced processes for uranium refining. This new example of our services in advancing uranium technology portrays Catalytic's position of leadership in the industry of tomorrow. We welcome your inquiries today —that Catalytic's on-time, on-budget services may contribute to your success of tomorrow.

CATALYTIC ON-TIME...ON-BUDGET SERVICES
for the atomic energy, chemical, petrochemical and oil refining industries • Project Analysis • Process Design • Economic Studies • Engineering • Procurement • Construction • Plant Operation

CATALYTIC
CONSTRUCTION COMPANY
1528 Walnut St., Philadelphia 2, Pa.
In Canada:
CATALYTIC CONSTRUCTION OF CANADA, Limited
Sarnia, Ontario

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ANNOUNCING NEW

Another LUNKENHEIMER "FIRST" . . .

Fig. 2600

LUNKEN

THE ONE *Great*

LUNCOR

Valves and Fittings

The Lunkenheimer PVC Valve resistant to industrial chemicals!

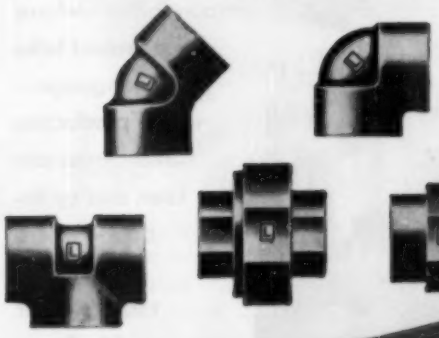
You can cut your corrosive fluid handling costs with the first all-plastic valve designed and engineered by a valve manufacturer!

The new LUNCOR Valve, by Lunkenheimer, is made of rigid, unplasticized PVC. Every part is completely molded — body, bonnet, stem, and handwheel. The molding process not only gives it amazing strength, but protects its resistance to corrosion. You get time-tested Lunkenheimer quality — at surprising savings. If you have been using stainless steel or alloy valves for corrosive service, it will pay you to investigate the new LUNCOR Valve and Fittings . . . *now.*

Basic material used for the LUNCOR Valve is polyvinyl chloride (PVC), which resists most industrial chemicals. It is recommended for service at pressures up to 125 psi and temperatures up to 140°F.

A complete line of LUNCOR PVC Fittings is also available from Lunkenheimer — 45° and 90° elbows, tees, flanges, unions, reducing bushings, caps, couplings, and plugs.

For full details, call your local Lunkenheimer Distributor, or write The Lunkenheimer Company, Box 360, Cincinnati 14, Ohio.



HEIMER®

NAME IN VALVES

L-1154

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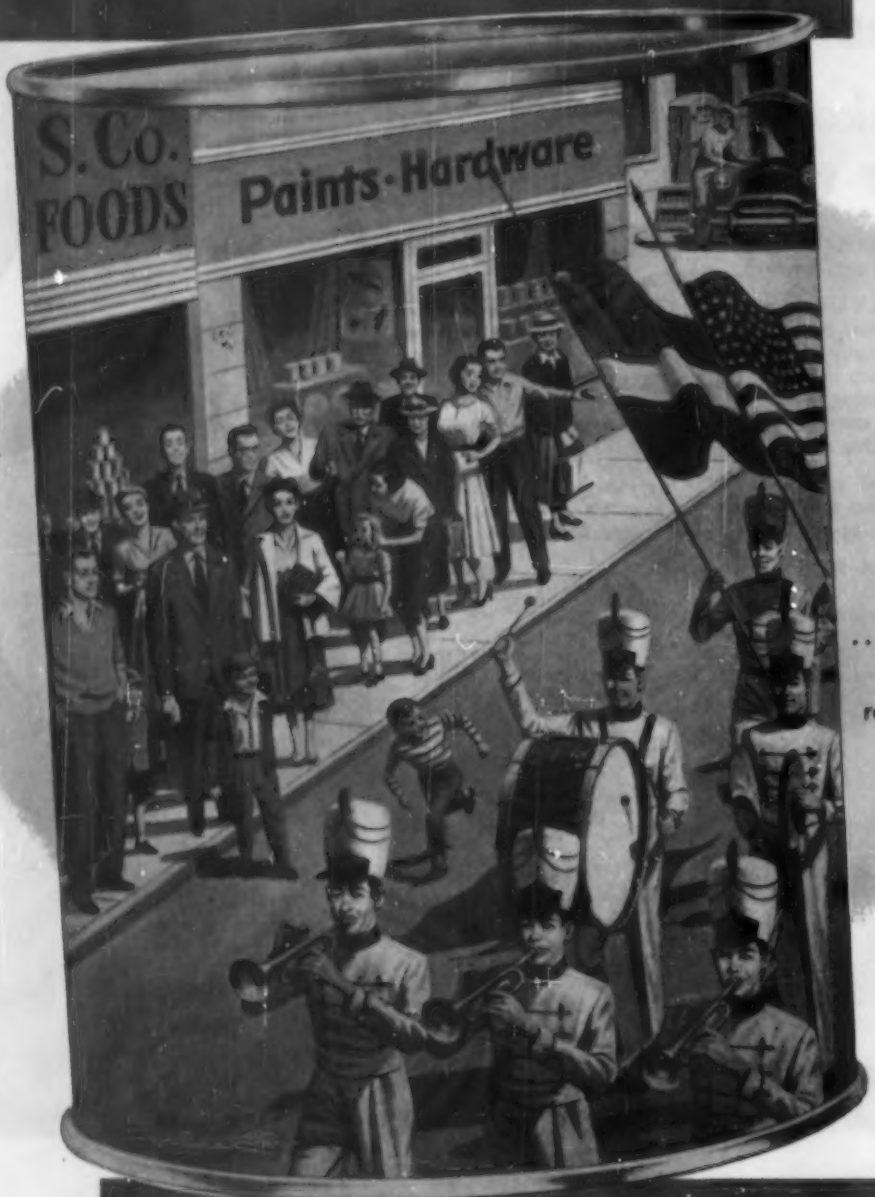
NATIONAL CAN

ON THE MARCH...



...with a new concept of business responsibility—where management talks your language—where production techniques are keen and up-to-date—where the future is today's order of business.

NC

NATIONAL CAN

CORPORATION

Plants At: BALTIMORE, MD. • CHICAGO, ILL. • MASPETH, N. Y.
CLEVELAND, OHIO • HAMILTON, OHIO and WARREN, OHIO

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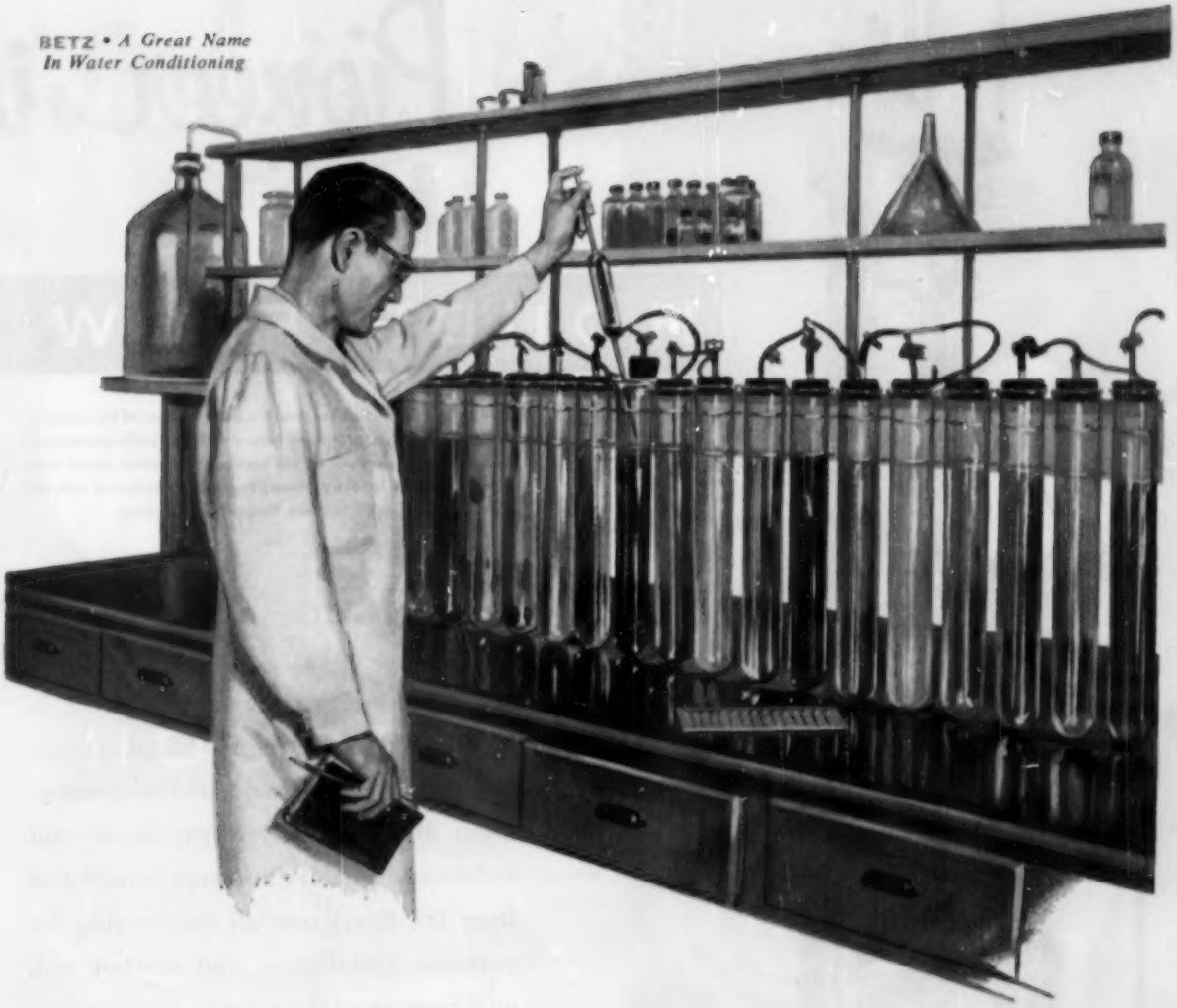
BETZ • *A Great Name*
In Water Conditioning



He's researching another first!

Big things are happening daily in industrial water conditioning . . . new developments . . . new discoveries . . . new techniques. As the leader in researching better ways to condition water, Betz is far out in front. The record speaks for itself. For example, Betz was

. . . *first* to develop an advanced method for the *complete* control of corrosion in condensate lines.

. . . *first* to develop an economical technique for the control of corrosion and pitting in recirculating cooling water systems.

. . . *first* to pioneer the use of effective antifoam agents for prevention of carryover.

. . . *first* to develop a practical method of silica removal from boiler feedwater.

These Betz firsts are *just a few* of the many industry-accepted water conditioning methods that have resulted from our *continuing* program of research. Many more are to follow.

Isn't this the kind of leadership and ability *you* want in water conditioning counsel for *your* plant? A Betz District Engineer will be happy to give you the details of Betz complete plant service. Talk to him today.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa.

In Canada: BETZ Laboratories Limited, Montreal 1.

BETZ

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

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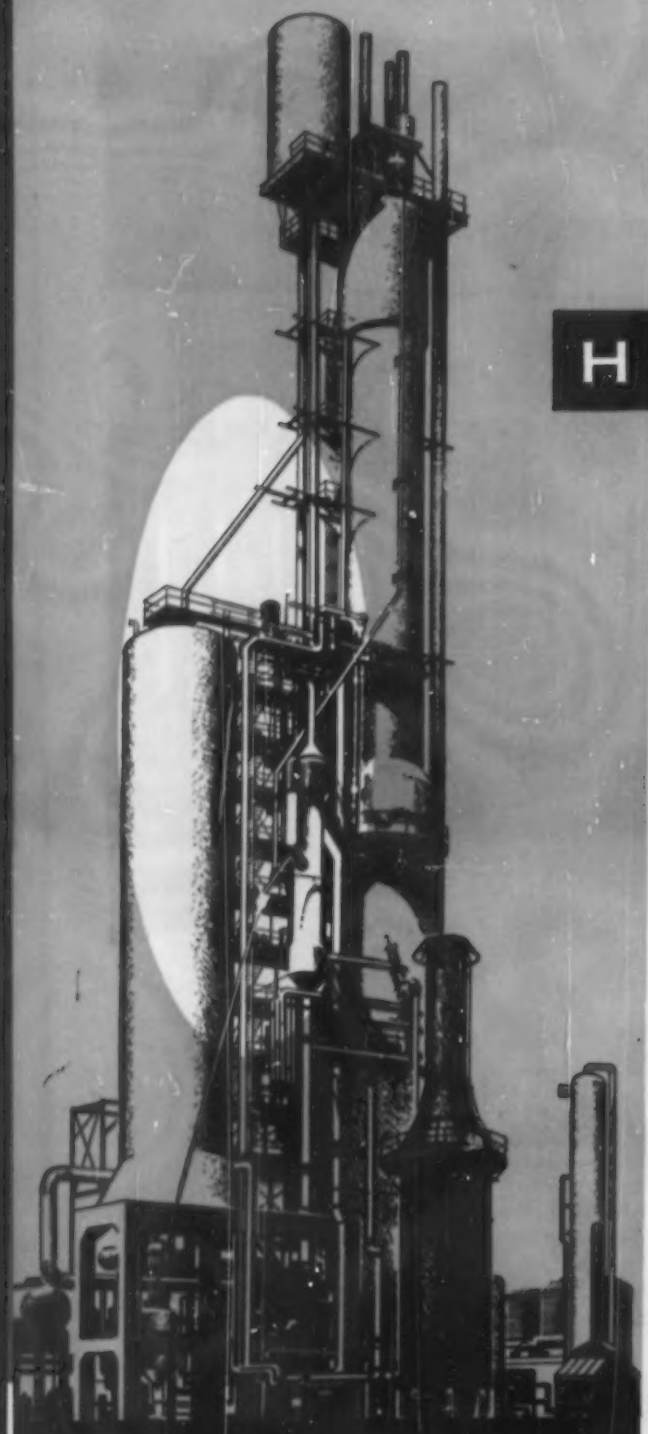


HOUDRY
PROCESS CORPORATION
PIONEER IN CATALYTIC PROCESSES

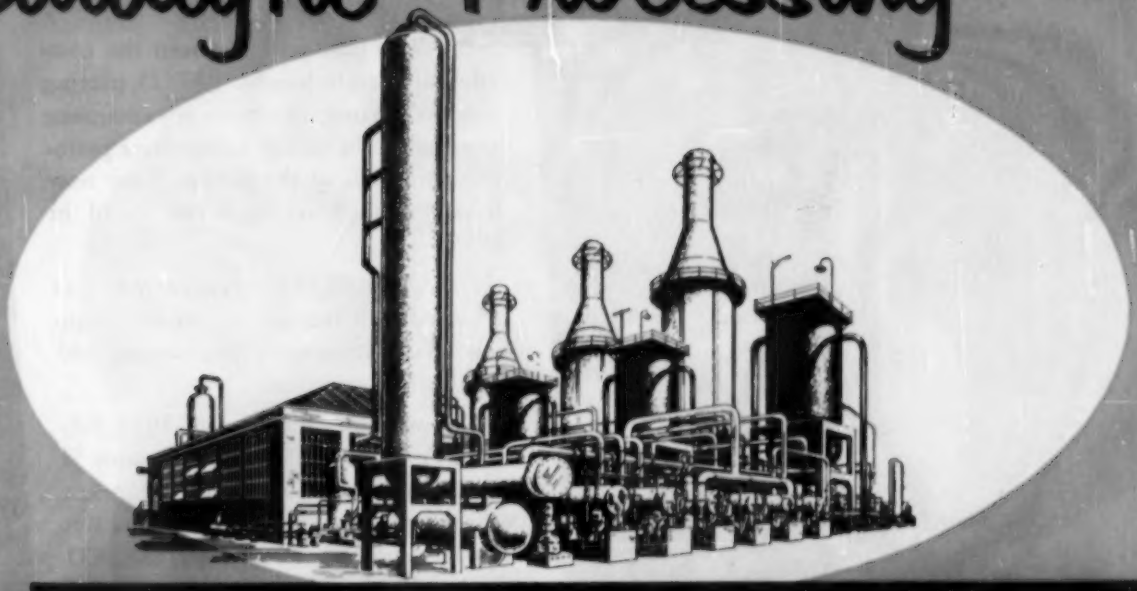
Pioneer in

HOUDRIFLOW

Houdriflow Catalytic Cracking, the most modern of the moving-bed processes, is providing many refiners with economical and efficient operation at the highest conversion levels ever achieved in the industry. Heavy fuel oil production is reduced to a minimum with modern Houdriflow cracking.

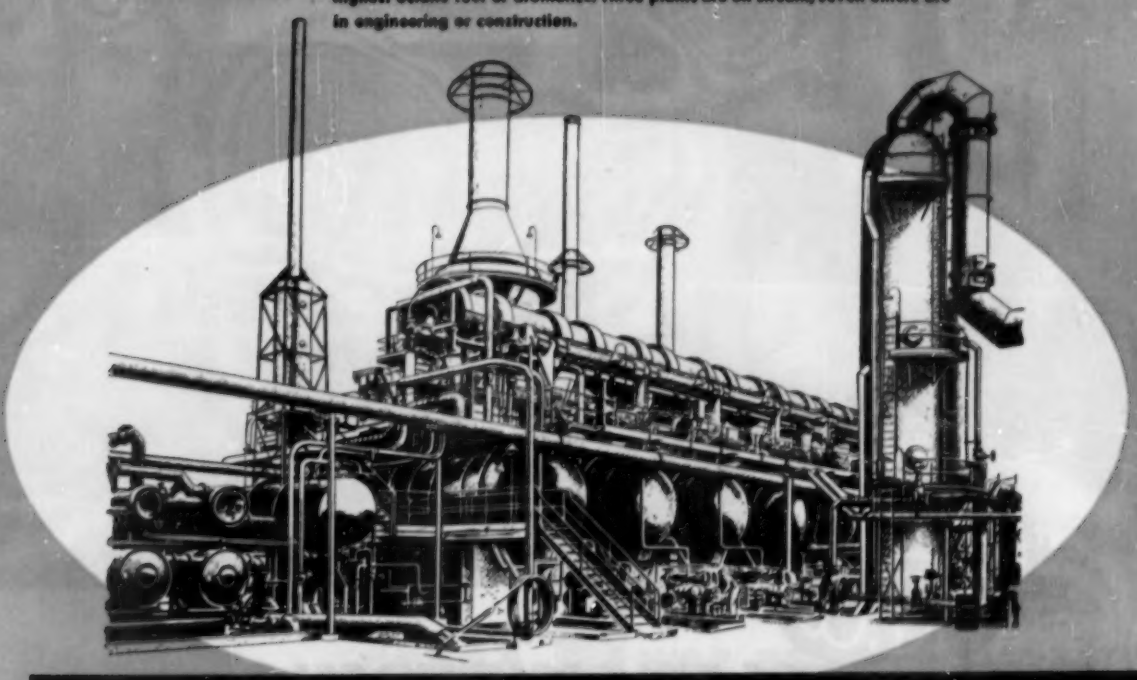
Houdry Process Corporation has twenty-seven years of catalytic process experience. Continuous, intensive research is maintained for the improvement of existing Houdry processes and the development of new catalytic processes and techniques. Houdry licensees benefit also from the finest over-all engineering experience, installation and start-up aid, and post on-stream technical service. Brochures describing Houdry catalytic processes are available. Yields, flow diagrams and other data are included. Write for copies to Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Penna. International licensor: World Commerce Corporation, S. A.

Catalytic Processing



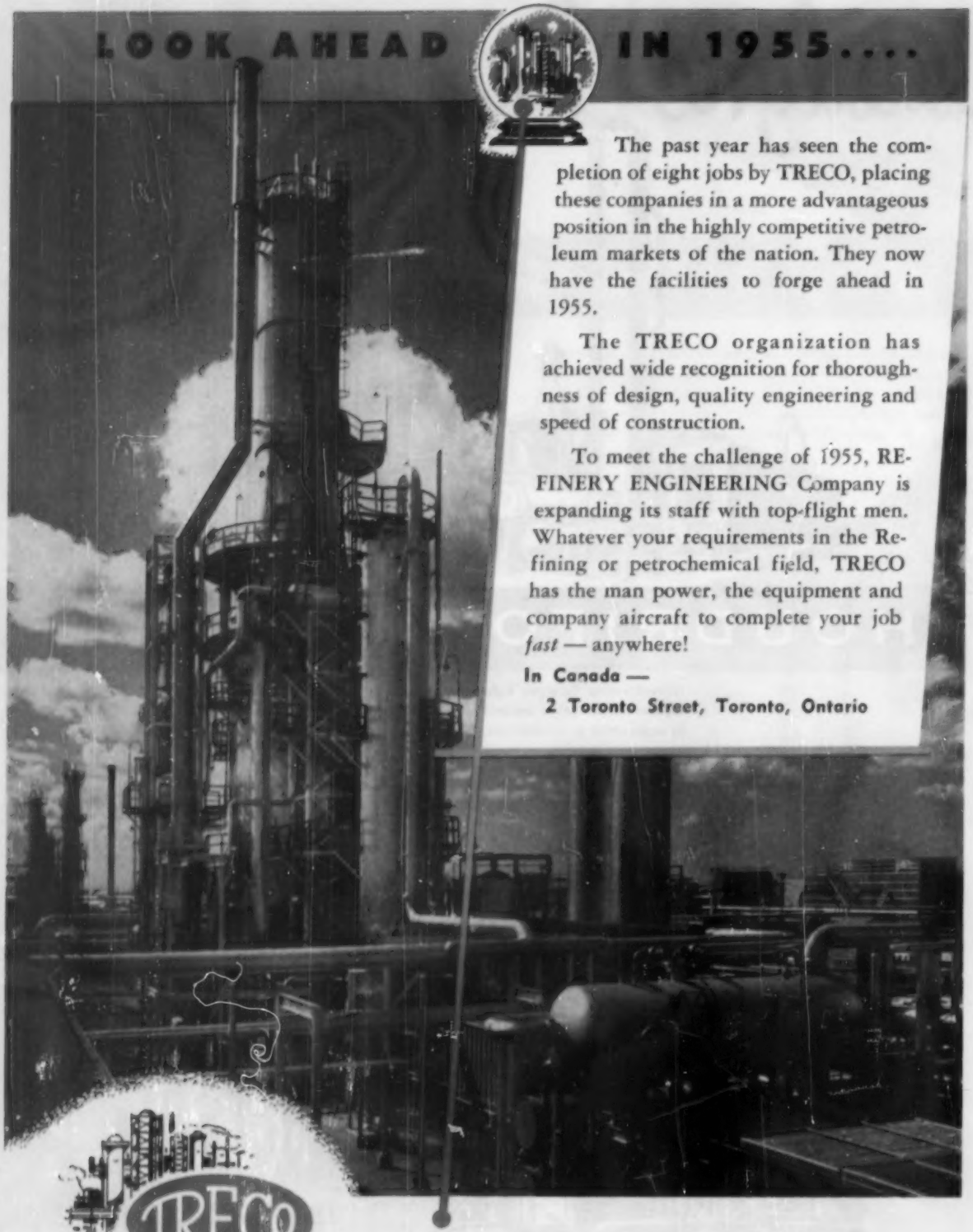
HOUDRIFORMING

Houdriforming Catalytic Reforming process is giving maximum yields of highest octane fuel or aromatics. Three plants are on stream, seven others are in engineering or construction.



HOUDRY DEHYDROGENATION

Houdry Dehydrogenation process is the only commercially-proved single-step process for the production of either butylenes or butadiene from low cost, plentiful butane. This process is adaptable to many other related conversions.



The past year has seen the completion of eight jobs by TRECO, placing these companies in a more advantageous position in the highly competitive petroleum markets of the nation. They now have the facilities to forge ahead in 1955.

The TRECO organization has achieved wide recognition for thoroughness of design, quality engineering and speed of construction.

To meet the challenge of 1955, REFINERY ENGINEERING Company is expanding its staff with top-flight men. Whatever your requirements in the Refining or petrochemical field, TRECO has the man power, the equipment and company aircraft to complete your job *fast* — anywhere!

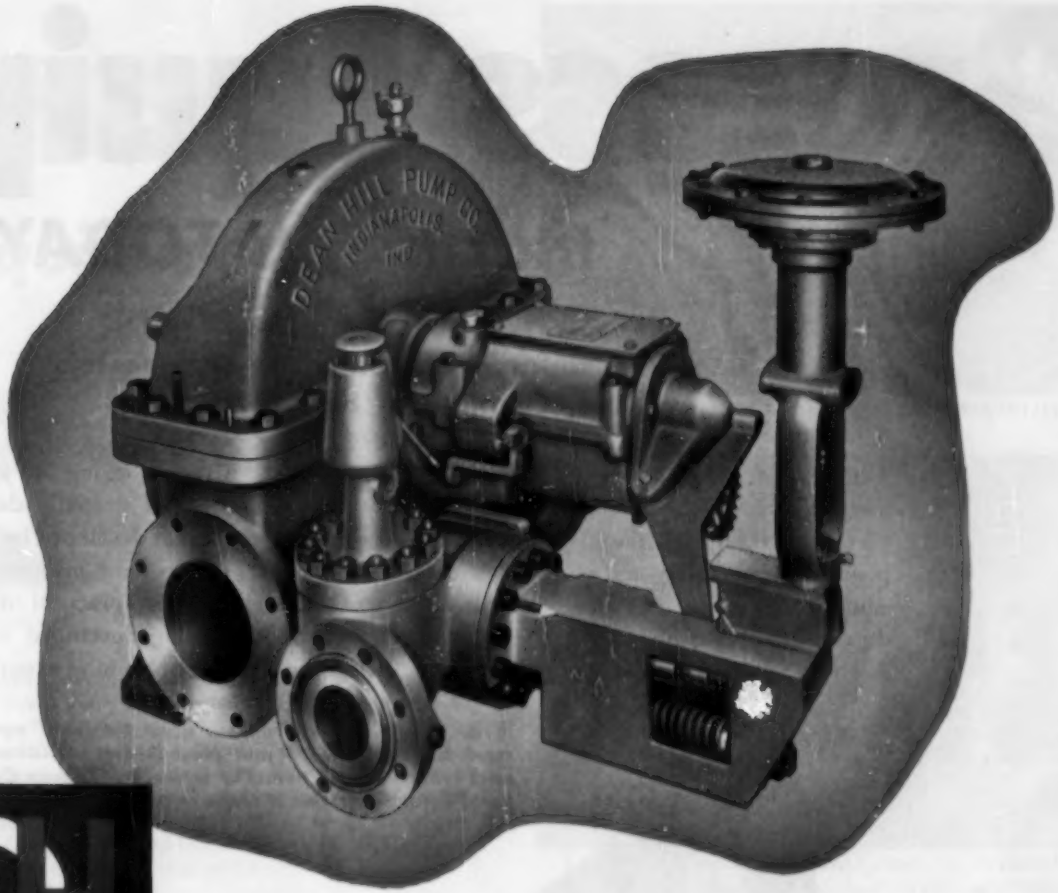
In Canada —

2 Toronto Street, Toronto, Ontario

TRECO

REFINERY ENGINEERING Company

TULSA TORONTO



D-H turbines with pressure regulators solve constant fluid pressure problems

Dean Hill Turbines equipped with pressure regulators are "made to order" for boiler feedwater applications requiring precise, automatic pressure control. Regulators can be used with any turbine model of either horizontal or vertical design and are furnished with direct-acting or remote control. They can be arranged to maintain a constant pump discharge pressure or a constant differential pressure over the boiler pressure.

The regulator controls all turbine speeds up to normal rating, but above this point the turbine governor overrides the regulator to prevent overspeeding. The emergency trip valve remains independent.

To effect maximum efficiency of control and eliminate lost motion and deflection, the regulator is mounted on a rugged support made of welded six-inch channels.

For further information on D-H Turbines and optional accessories

write today for Catalog 500.

DEAN HILL PUMP COMPANY

Pump and Turbine Engineers Since 1893

Indianapolis 7, Indiana

Sales Offices In:

Chicago, New York, San Francisco, Boston, Cincinnati, Denver, Albuquerque, El Paso, Salt Lake City, New Orleans, Philadelphia, Tulsa, Los Angeles, Pittsburgh, Houston, Dallas, St. Paul, Toledo, Cleveland, Grand Rapids, Birmingham, Ala., Louisville, Memphis, Richmond, Mexico City, Montreal, Reading, Pa., The Hague, Washington, Charlotte, Casper, Wyo., Knoxville.

Process Equip

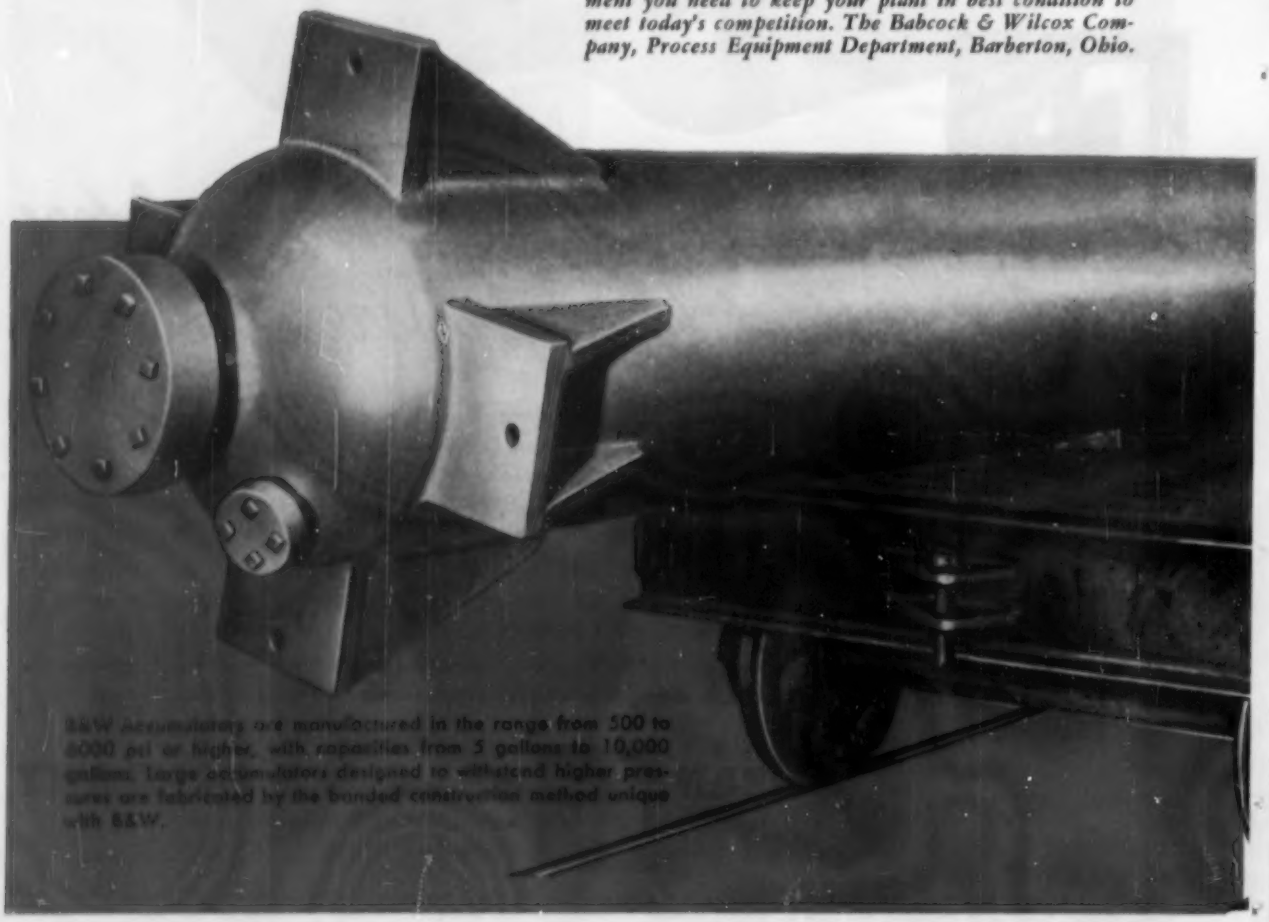
that meets TODAY'S

B&W Accumulators and other Pressure Vessels
• Alloy Castings • Hollow Forgings

The constant progress being made within the process industries demands the utmost of the engineers responsible for the dependability, efficiency and economy of the equipment that serves today's process industries' requirements.

At B&W, forming, machining, welding, X-raying and stress relieving are all performed on equipment specially designed for the job, much of it developed by B&W. And for temperature and pressure problems that arise, new and practical solutions are continually being developed through designing skill based on long experience.

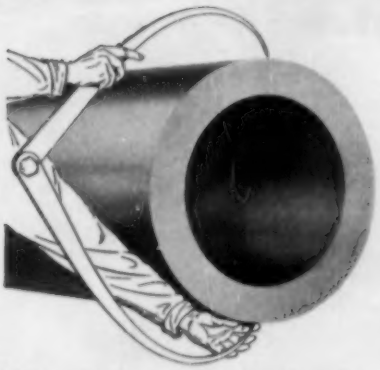
Write for detailed information about the B&W equipment you need to keep your plant in best condition to meet today's competition. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.



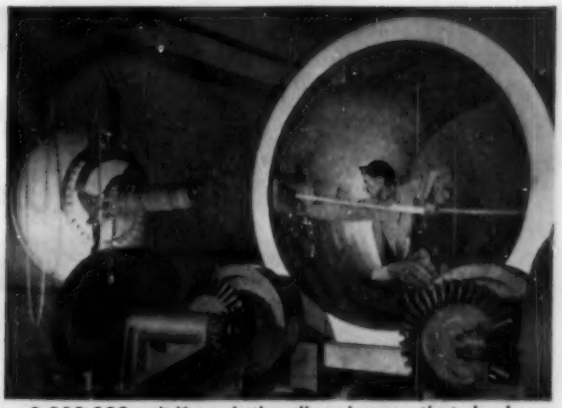
B&W accumulators are manufactured in the range from 500 to 6000 psi or higher, with capacities from 5 gallons to 10,000 gallons. Large accumulators designed to withstand higher pressures are fabricated by the bonded construction method unique with B&W.

ment

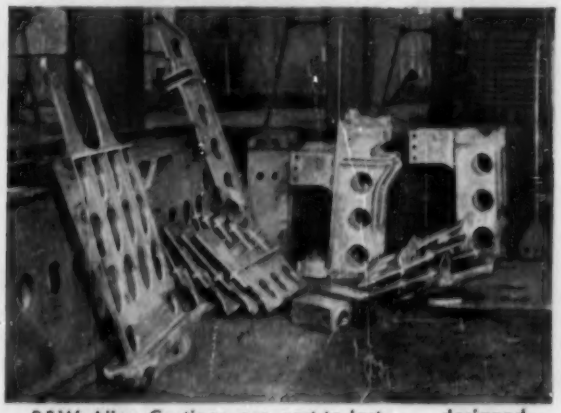
requirements



B&W Hollow Forgings are large-diameter, heavy-wall pipes or tubes that offer the designer the advantages of single lengths or many lengths, "tailor-made" to his requirements . . . prompt delivery even on small orders . . . full forging properties resulting from thorough working of the metal . . . excellent concentricity . . . a wide size range. They are supplied in a wide range of carbon and alloy steels, produced in accordance with ASTM Specifications A106, A266, and A335.



2,000,000-volt X-ray is the all-seeing eye that checks the soundness of welds.



B&W Alloy Castings are cast-to-last . . . designed for long life under the most rigid service conditions requiring superior resistance to abrasion, high pressures and high temperatures.

B&W's giant new press, used in making Hollow Forgings and other products needed to meet industry's growing demands.

S-434

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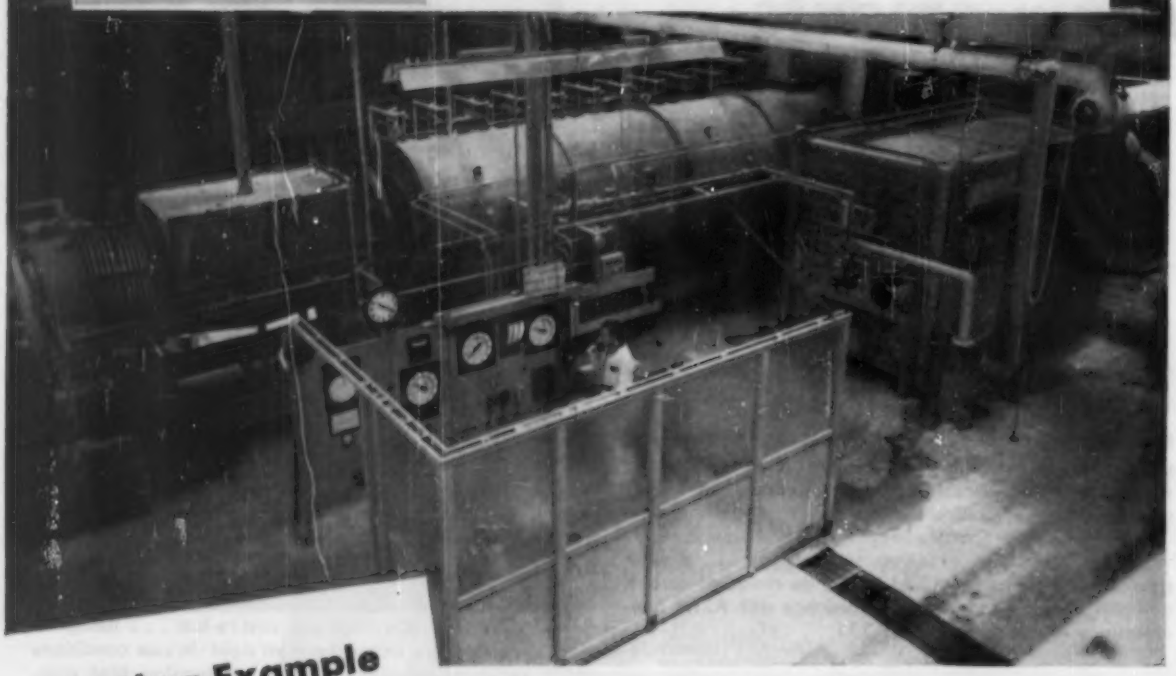
Nalform

FLUID HYDROFORMING CATALYST PRODUCTION CAPACITY . . .



another Example of Service to further Petroleum Industry Progress

● Fluid hydroforming to upgrade petroleum products is one of the typically rapid advances in the Petroleum Industry that the Nalco Catalyst Division is proud to have had a part in making possible.

Standard Oil Development Company and Nalco Catalyst Division worked together in developing Nalform Hydroforming Catalyst. In a surprisingly short time, Nalform was being produced in commercial quantities.

Nalform and Nalcat Catalysts are good examples of the abilities and facilities of Nalco Catalyst Division to produce and provide service to match petroleum industry progress.

Nalcat · Nalform

Production and Service to Match Petroleum Industry Progress

CATALYST DIVISION — NATIONAL ALUMINATE CORPORATION
4001 West 71st Street • Chicago 29, Illinois

10 REASONS WHY

LEADING REFINERS RELY ON KONTOL FOR PROTECTION AGAINST CORROSION

1. Kontol protects against attack by organic and inorganic acids and brines which cause corrosion, hydrogen blistering and embrittlement.
2. Kontol effectively protects steel, nickel and stainless alloys of steel, monel, brass and admiralty metal.
3. Kontol offers detergent action as well as inhibitive properties. It also assures the advantages of operations with clean units and flow systems.
4. Kontol has no adverse effects on distilled product properties such as distillation end point, gum formation, anti-knock rating, ash, etc.
5. Compared with the replacement costs of the equipment it protects, the cost of Kontol protection is negligible.
6. Kontol is convenient and safe to handle, easy to apply. No gloves, masks, goggles, aprons or extraordinary safety precautions are necessary.
7. Kontol is available in many formulas, to meet varying requirements. It can be oil soluble; oil soluble and water dispersible; water soluble and oil insoluble.
8. Kontol, in the appropriate formula, is miscible in all proportions with aqueous alkaline agents and can be injected through the same system.
9. The Tretolite commercial testing staff will carry on tests to determine the rate of corrosion in your refinery, at no cost to you.
10. Kontol has been proved to provide protection against corrosion in

CAT CRACKER FRACTIONATORS
CRUDE STILLS
DEPROPANIZERS
DEBUTANIZERS
DEPENTANIZERS
GAS RECOVERY SYSTEMS
ABSORBERS
STABILIZERS
PLATFORMERS
REFORMERS
DESULFURIZATION SYSTEMS
VACUUM TOWERS
ALKYLATION PLANTS
COKING SYSTEMS
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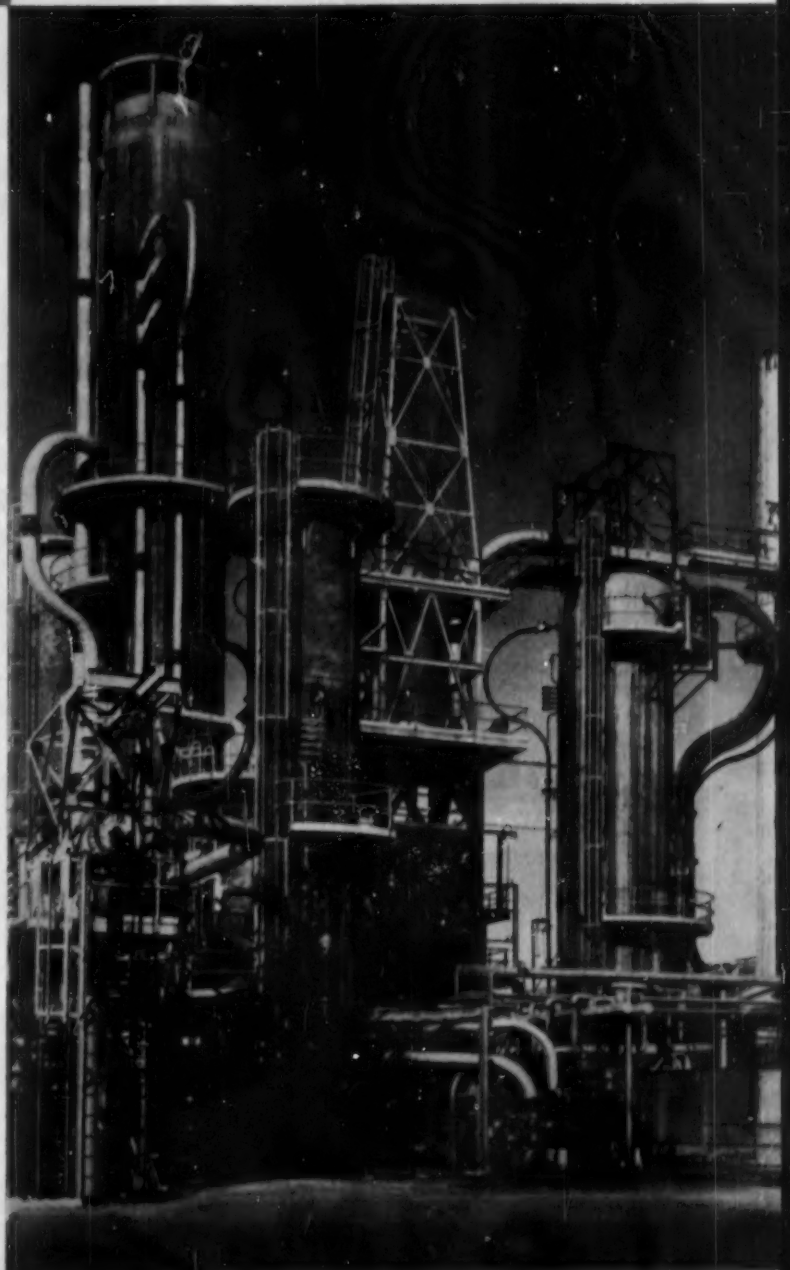
ALKANOLAMINE SWEETNERS

TRETOLITE COMPANY
KONTOL
ST. LOUIS • LOS ANGELES

Chemicals and Services for the Petroleum Industry

DESALTING • CORROSION INHIBITING • WATER DE-OILING
DEMULSIFYING • SCALE PREVENTION • ASPHALT ADDITIVES



If you have a corrosion or fouling problem, get in touch with the Tretolite refinery service engineer in your area or write to

TRETOLITE COMPANY

A DIVISION OF PETROLITE CORPORATION

369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

Dependable S&J SWING LINE ASSEMBLY

Fig. ST-235

Swing line equipment for petroleum storage tanks can only be as efficient and dependable in operation as its design and manufacture make it. You can be assured that Shand & Jurs Swing Line assemblies possess that top notch QUALITY that set them head and shoulders above the rest. Consider these features of S&J's Swing Line Assemblies that provide long life operation and greater dependability under all weather and operating conditions:

The S&J Double Elbow Swing Joint, Fig. ST-235, is designed for mounting on the tank shell only. Settling or shifting of the tank bottom cannot affect its free and easy swing. The two elbows are held together by a spring loaded rod and tension can be adjusted. The swivel elbow is supported by a thrust bearing which is tied to the tank shell by telescoping supports that facilitate installation. Telescoping supports are supplied only when specified.

Fig. ST-4380

The S&J Cable Winch, Fig. ST-4380, utilizes machine cut, anti-backlash gears which run in an oil bath. The handle is designed to provide maximum mechanical advantage with minimum effort.

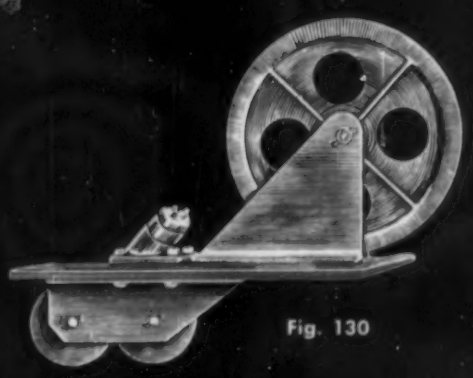


Fig. 130

The design of the S&J Cable Sheave Bracket, Fig. 130, assures proper alignment of the plow steel cable passing through the tank roof and over the exterior sheave. Also available are S&J Gas Tight Cable Sheave Cases which provide an oil seal for moderate tank pressures.

Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
342 Madison Ave.

HOUSTON
M & M Bldg.

TULSA
Thompson Bldg.

CHICAGO
10409 S. Western Ave.

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714 W. Olympic Blvd.

REPRESENTATIVES:
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MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
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VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
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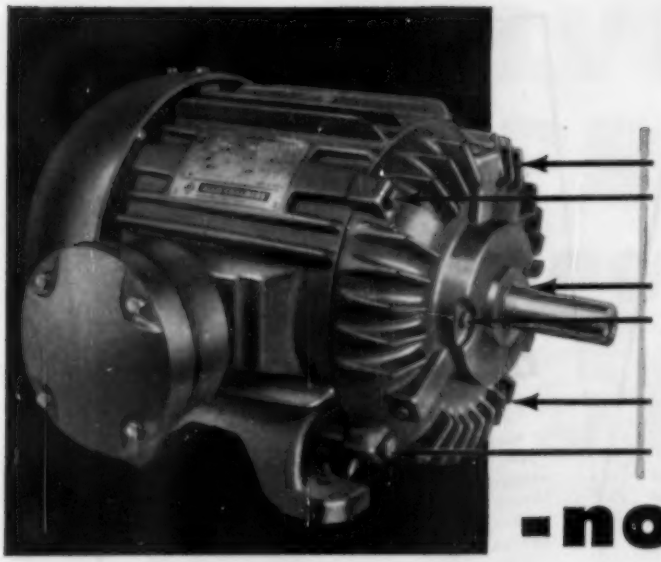


It takes Six Bolts -not just four

to give full bearing protection for greater motor performance

THE TWO EXTRA BOLTS in the end housing of every Allis-Chalmers ball bearing motor are the proof of *extra* protection against bearing failure. These are the bolts that hold the bearing cap tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure . . . protects the grease and the bearing against contamination from dirt and moisture.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

Result? Allis-Chalmers motors pay off in longer, trouble-free bearing life, lower motor maintenance.

Get all the facts . . . judge for yourself — Compare Allis-Chalmers motors with other motors. Get the six-bolt construction that gives you complete bearing protection. For proof, see your Allis-Chalmers Office or Authorized Distributor, or write — Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS A-C

A-4541

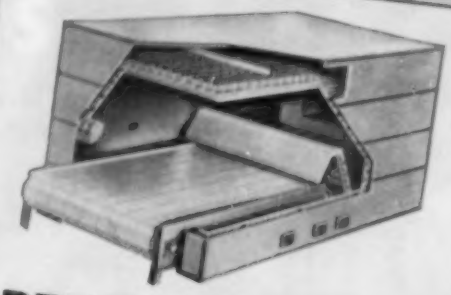
MOIST FUEL CELLS

An important application of B-L unit-suspended walls and arches is found in furnaces where a fuel with a high moisture content is burned. Although designed primarily for use in cane sugar countries for bagasse burning, these furnaces have proven so successful in other fields such as the burning of bark and wet wood refuse.

BIGELOW-LIPTAK *Corporation*

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*



DRYER FURNACES

A tough assignment for a furnace is to stand up under the every-day beating of heat in drying applications. B-L's streamlined thin wall dryer furnace does it—cuts maintenance to boot. It furnishes heat for drying coal, sugar, salt, lumber, chemicals.

BIGELOW-LIPTAK *Corporation*

LOWEST MAINTENANCE

When you specify a B-L furnace enclosure you can be sure of long life and lowest possible maintenance. Intelligent engineering and top-quality materials provide the stand-up stamina that makes enclosures "tougher than blazes." Each unit is individually designed for the job. Write today for complete information.

Castable Linings

B-L's castable lining for oil refining furnaces provides a smooth monolithic wall capable of resisting abrasion and standing up under high heat demands. The construction is adaptable to catalytic regenerators, catalytic reactors, cyclones, stacks and other refinery equipment.

BIGELOW-LIPTAK *Corporation*

UNIT-SUSPENDED WALLS AND ARCHES

BIGELOW-LIPTAK *Corporation*

AND BIGELOW-LIPTAK EXPORT CORPORATION

2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

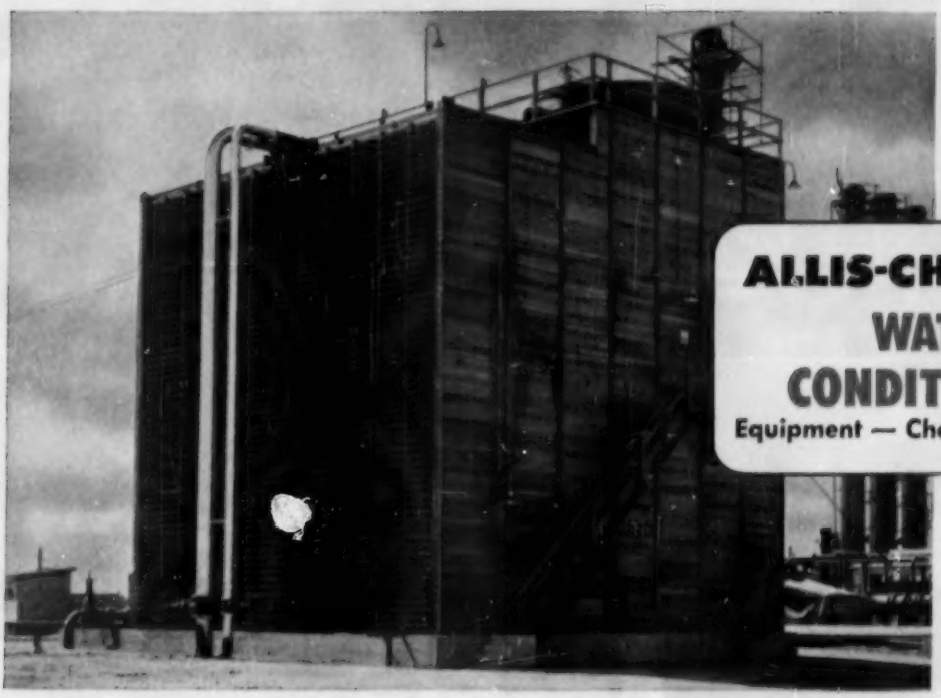
UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*

ATLANTA • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MINNEAPOLIS • NEW YORK
PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SAULT STE. MARIE, MICH. • SEATTLE • TULSA • VANCOUVER, B.C.

4150

SOLVING WATER PROBLEMS in Cooling Towers



ALLIS-CHALMERS WATER CONDITIONING
Equipment — Chemicals — Service

Use of cooling towers to save on water brings unusual problems. Some of these problems are corrosion, scaling, algae and slime, and deterioration of wood in the tower. Allis-Chalmers recently published an informational bulletin, Number 47A, which explains the causes of these problems and what can be done about them.

Part of Practical Library

This bulletin is one of a series published by Allis-Chalmers to help you understand the causes and solutions of many water problems. It is the result of Allis-Chalmers experience solving water problems for every industry, in addition to solving problems involved in the company's own broad line of steam turbine and power plant equipment.

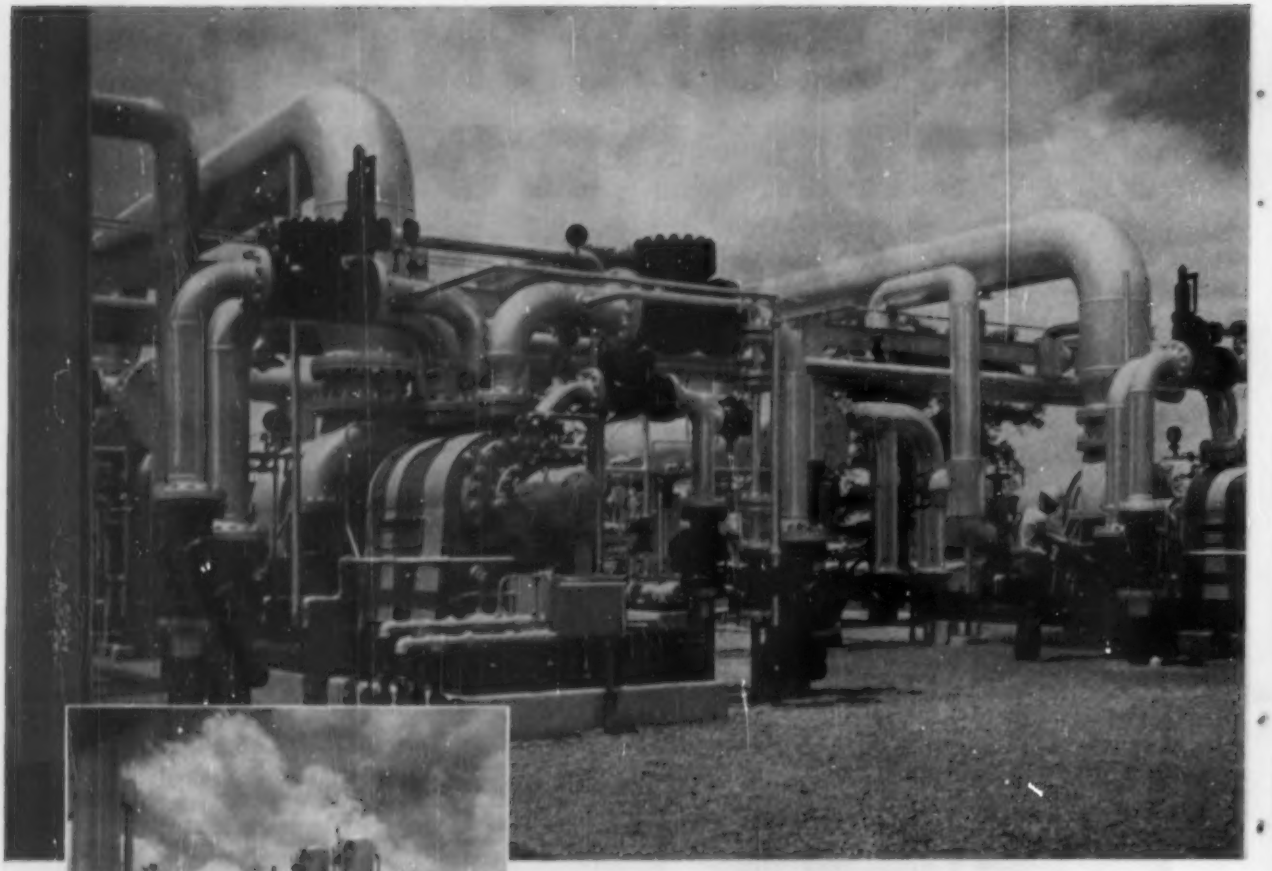
Complete Water Conditioning Service

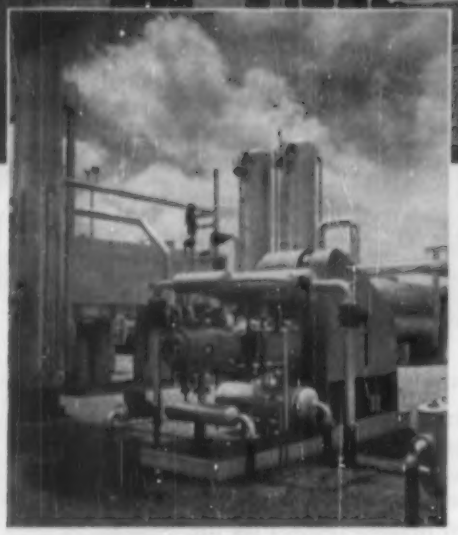
Allis-Chalmers offers complete water conditioning service. You can get analyses and reports on your problems. You can get chemicals needed in water treatment. And you can get the equipment needed for any system.

A-4316

Get Information — For your copy of Bulletin 47A on water treatment for cooling towers, write Allis-Chalmers, Milwaukee 1, Wisconsin. Or better, call your nearby A-C district office to have an Allis-Chalmers water conditioning engineer consult with you on your problems.

ALLIS-CHALMERS





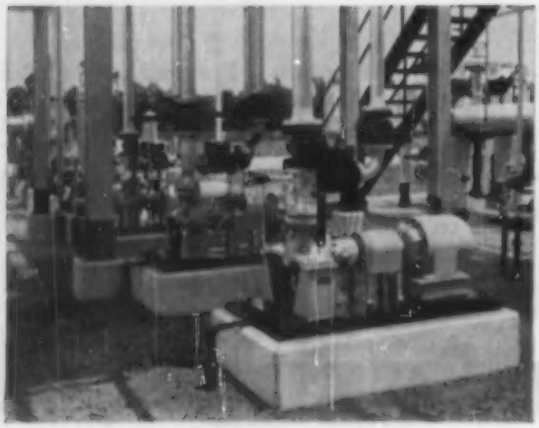
Each of these seven-stage Class CHTB I-R pumps is on lean oil service discharging to absorbers at three pressure levels: 400, 700 and 1450 PSIG. Note the neat arrangement of three sets of discharge lines.

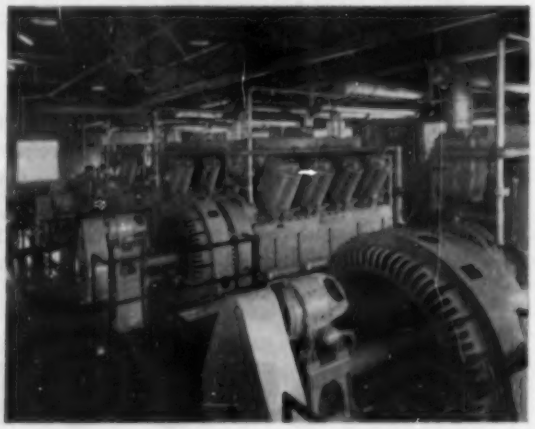
This 2-stage, motor-driven Class ES compressor handles still vapors.

Three I-R Type SVG 6-cylinder gas engine compressors handle flash gas, to demethanizer.

Ingersoll-Rand SFLA pumps, with integral mechanical shaft seal, on reflux service.

These four PSVG8 380 kw gas engine generators supply all plant electric power.

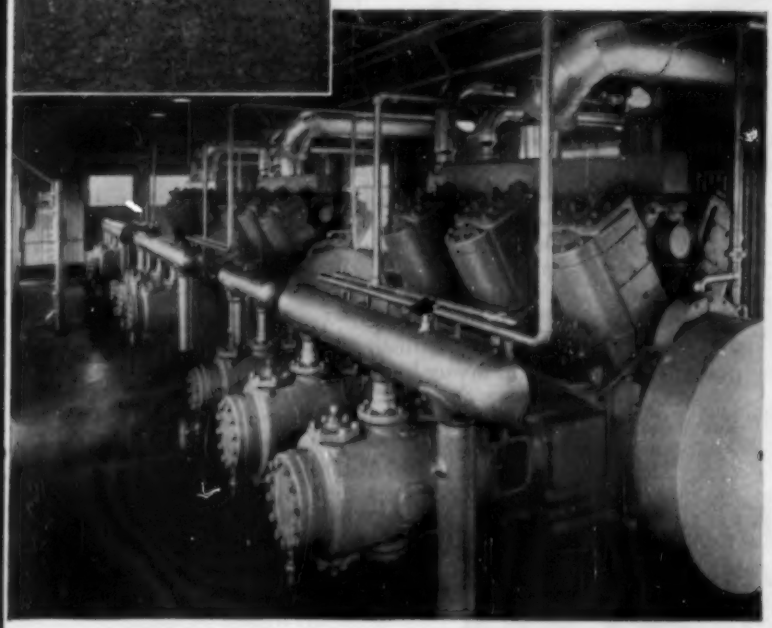




New PLEDGER GASOLINE PLANT operated by SOUTHERN PRODUCTION COMPANY, INC.

"ON STREAM..."

with I-R pumps, gas-engines and compressors used on all processing services



This outstanding natural gasoline plant, engineered and constructed by Stearns-Roger Manufacturing Co. processes 190 million cubic feet of natural gas per day.

Ingersoll-Rand equipment is used throughout the processing operations at Pledger. Centrifugal pumps, ranging in size from 3 hp Motorpumps to 2000 hp double-case lean oil feed units, handle the plant's liquid products in all stages of preparation. I-R compressors, in steam, electric and gas-engine-driven types, fill the plant's compressor requirements—and I-R gas engines generate 1520 kw of auxiliary power.

The new Pledger Gasoline Plant is another excellent example of how Ingersoll-Rand can meet the needs of the processing industry with equipment that is known the world over for dependability and fine workmanship. Our branch offices will be glad to help solve your pumping, compressing or power-generation problems. Their long experience is at your service.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

14-101

PUMPS • COMPRESSORS • GAS & DIESEL ENGINES • TURBO-BLOWERS • VACUUM EQUIPMENT • AIR & ELECTRIC TOOLS

For more data on advertised products, use Readers' Service Cards, last page.

avoid freeze-ups

...use Yarway impulse steam traps

Don't take chances with equipment freeze-ups and costly production delays. Put Yarway Impulse Steam Traps on all lines subject to freezing temperatures.

There's no danger of your lines freezing with Yarway traps. Condensate does not collect. The only moving part of the trap—a little valve—continually tests for condensate, discharges each bit as it forms.

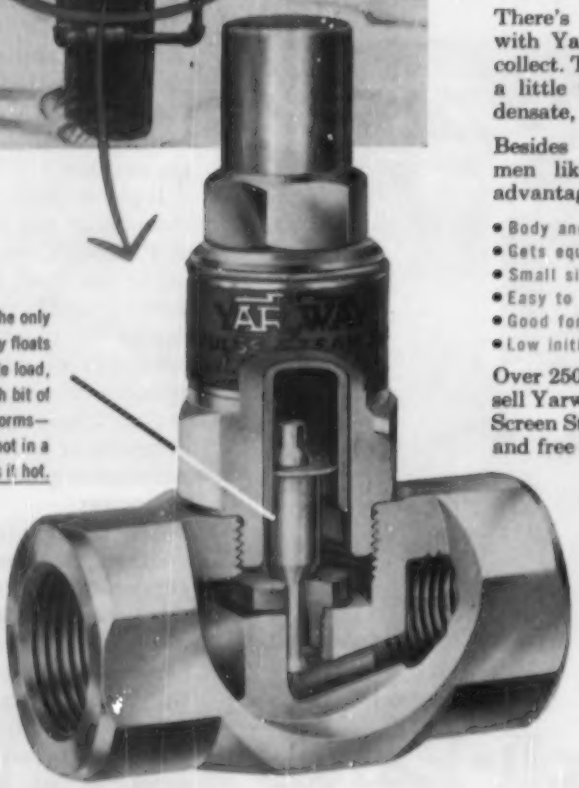
Besides this non-freezing feature, plant men like these other Yarway Impulse advantages:

- Body and all working parts are stainless steel
- Gets equipment hot in a hurry and keeps it hot
- Small size . . . light weight
- Easy to install . . . easy to service
- Good for all pressures
- Low initial cost

Over 250 Industrial Distributors stock and sell Yarway Impulse Steam Traps and Fine Screen Strainers. For name of one near you and free trap booklet, write . . .

YARNALL-WARING COMPANY
128 Mermaid Ave.
Philadelphia 18, Pa.

This little valve, the only moving part, actually floats on the condensate load, discharges each bit of condensate as it forms—gets equipment hot in a hurry and keeps it hot.



YARWAY impulse® steam traps

For more data on advertised products, use Readers' Service Cards, last page.

TYPE 8-B

at RICHFIELD'S NEW WATSON REFINERY

Here, at the largest and most modern refinery on the West Coast, you'll find a complete line of "John Crane" Seals. Specifically designed for refinery service, these seals were selected for their ability to handle difficult liquids.

For instance, you'll find Type 8-B Seals handling propane at 100°F., 700 psi., spg. 0.475 . . . Type 1-B Seals on 4-stage pumps handling liquids at 190°F., 500 psi . . . Type 2 Seals in ethane-butane service at 90°F., 235 psi . . . others handling gasoline at 110°F., 445 to 460 psi.

These seals, in combination with the "John Crane" Type 9 Seal (incorporating sealing member of DuPont Teflon), are used in refineries everywhere.

The "John Crane" Type 9 Seal is especially adapted to handling light hydrocarbons and similar services where rubber sealing members cannot be used because of high temperatures and corrosive action.

Refinery engineers should have our new and latest literature on "John Crane" Seals.

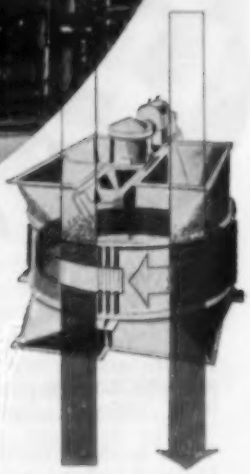
Crane Packing Company, 1820 Cuyler Avenue, Chicago 13, Illinois

In Canada: Crane Packing Company, Ltd., 617 Parkdale Ave., N., Hamilton, Ont.

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

with the

Ljungstrom Air Preheater



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

In every processing vessel that burns fuel, air preheat shows the way to save as much as *one barrel out of every five*. When refineries alone burn over 200,000,000 barrels every year, this means the *Ljungstrom Air Preheater* can recover tens of millions of *production dollars* that are now going up the stack.

The Ljungstrom removes precious BTU's from exit gases and transfers them to combustion air. Its effectiveness can be gauged from the fact that every 35-40°F of preheat means roughly a 1% saving in fuel—and Ljungstroms now in use preheat air to over 600°F.

In addition to saving as much as 20% of your fuel, more effective fuel utilization means that your equipment can deliver greater throughput . . . can burn lower grade fuels with less slagging . . . lets you eliminate convection surfaces without reducing production.

In these days of high fuel costs, every process industry should consider the Ljungstrom for new installations or modernization of existing equipment. Call or write The Air Preheater Corporation for full details.

Wherever You Burn Fuel, You Need Ljungstrom

THE AIR PREHEATER CORPORATION 60 East 42nd Street, New York 17, N. Y.

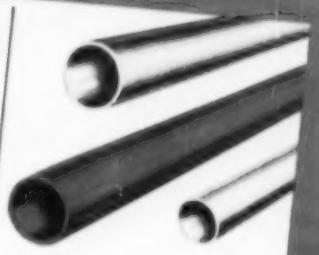
Only ONE Manufacturer

Supplies all these Condenser Tubes . . .

Yes, that's right! Only Wolverine Tube produces such a wide range of condenser tubes. That's flexibility—the kind that assures the product that's right for the job.

More important to you is the fact that only Wolverine breathes Tubemanship into its products: quality control, imagination, research—the plus values that mean extra-long life, greater efficiency for your installations.

Prime Surface Tubing



On some jobs it is logical to pick a prime surface condenser tube. Because of the varying corrosive conditions encountered, Wolverine produces prime surface tubing in a variety of metals: copper and copper-base alloys, aluminum and electric-welded steel. Naturally, like all Wolverine products, this type of tubing is available in a wide range of sizes.

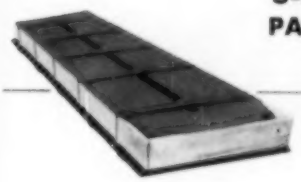
WOLVERINE TUBE

WOLVERINE TRUFIN* TYPE S/T

Frequently it is desirable to pack more heat transfer area into the available space. This is a job for Trufin Type S/T—Wolverine's extended surface integral-finned condenser tube. The fins resist the damaging shock of vibration and sudden temperature changes. You can directly replace prime surface condenser tubing with Trufin Type S/T—roll or braze it into headers by conventional means. It's available in a variety of metals with four different kinds of end finishing.

WOLVERINE TUBE

U-BEND PALLETS



Either finned or prime surface tubing can be furnished in U-bends—prearranged to your prints. That simply means that the tubes for an entire condenser are shipped on a disposable, box-type pallet. Each U-bend is fed directly from pallet to condenser—a distinct savings of time, storage space, inventories.

WOLVERINE TUBE

WOLVERINE TUBE
DIVISION OF CALUMET & HECLA, INC.
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Write today for a copy of the Wolverine book "An Opportunity." It will show you how to cut costs—increase efficiency of condenser units.

*REGISTERED U. S. PATENT OFFICE

that's Wolverine's FLEXIBILITY

Duplex

PRIME SURFACE CONDENSER TUBING

When two entirely different corrosive conditions are encountered, Wolverine can supply a Duplex tube—one which consists of tubes of two entirely different alloys. For example, the condenser tube illustrated consists of an electric-welded steel tube with a liner of inhibited Admiralty. Any two metals can be used—the determining factor simply being the type of corrosion expected.

WOLVERINE TUBE

Duplex | TRUFIN TYPE S/T

Naturally there are applications where only a Duplex tube can be used and yet extra condensing capacity is demanded. That's a job for Duplex S/T. For example, the condenser tube above has a finned copper tube outside and a liner of steel. Combinations like these resist two entirely different corrosion problems. When retubing condensers, Duplex S/T can be easily interchanged with prime surface tube; it has a plain end slightly larger than the O.D. of the fins so that it can be rolled into headers easily. It also has a ferrule of the liner material.

WOLVERINE TUBE

WOLVERINE TRUFIN* TYPE L/C

There are many applications—air cooling of jacket water, oil, condensing steam or hydrocarbon vapors—where Trufin Type L/C is the answer. This type of condenser tube has a high-finned exterior tube of aluminum and a liner available in a variety of metal to meet your specifications. Trufin Type L/C provides a maximum rate of heat transfer over a long period of operation.

WOLVERINE TUBE

Naturally, the selection of the right type of condenser tube is a tough job—one that's solved only by a complete survey of the job to be done. That's why Wolverine has set up its Field Engineering Service. You get complete help—suggestions on alloys, heat transfer, corrosion problems. That's the type of service that puts you ahead of the game—the type that makes Wolverine your surest source of supply.

*Wolverine Trufin is available in Canada through the Wolfe Tube Company, London, Ontario

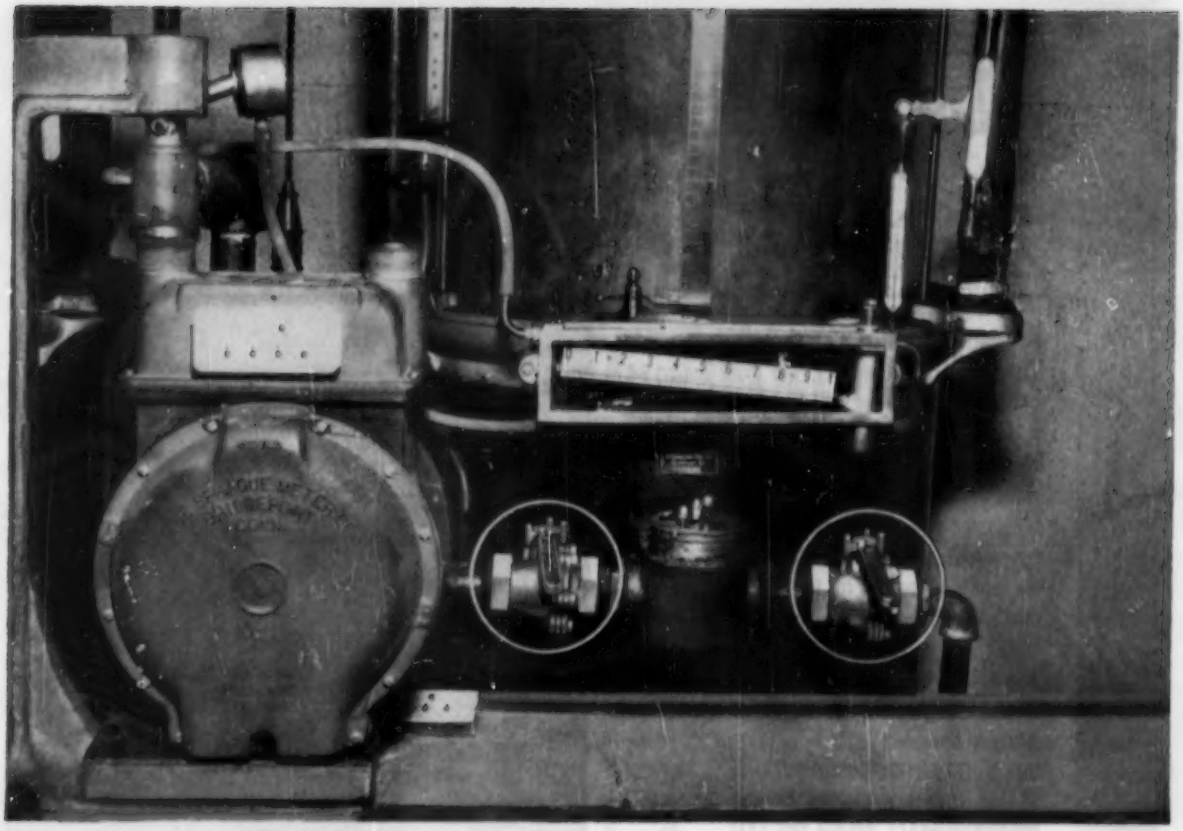
"Heat Exchanger and Condenser Tubes." You can have a copy of this handy book if you write for it on your letterhead . . . today! WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.

REGISTERED U.S. PATENT OFFICE

WOLVERINE TUBE
DIVISION OF CALUMET & HECLA, INC.
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPARTMENT, 13 EAST 40th STREET, NEW YORK 16, N.Y.



Meet the valves that open, close, . . . 1000 times a day!

The Sprague Meter Company, Bridgeport, Connecticut, uses Rockwood Ball Valves in air lines testing gas meters.

One thousand times a day, the valves are opened and closed. Yet they have completed two years' steady service without leakage, without maintenance!

This leakproof trouble-free performance is typical of the way in which Rockwood Ball Valves handle everything from L. P. G. to pickling acids, alcohol to asphalt. Used throughout the petroleum field, their efficiency stems from these four exclusive features —

Full Round Flow — no change in shape or volume of fluid stream — no turbulence — no minimum loss

Quick Opening and Closing — only a quarter turn needed

Longer Wear-Resistance — chrome-plated bronze ball withstands abrasion, pitting and scratching

Leakproof Seal — pressure of fluid automatically positions ball against seat to form tight seal.

If you are not now using Rockwood Ball Valves, send coupon today for complete information. Valves come in all pipe sizes. Tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD SPRINKLER COMPANY
561 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

Name_____

Title_____

Company_____

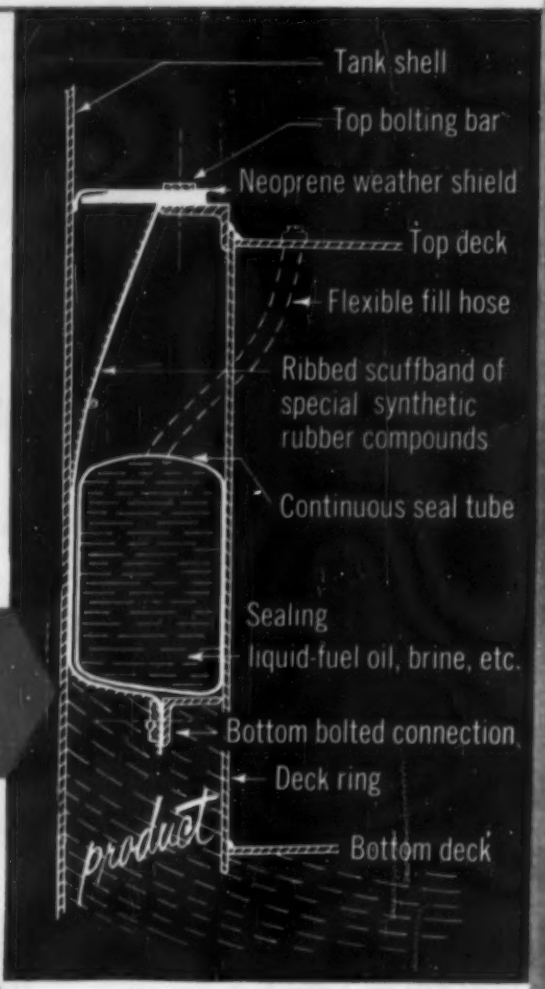
City_____

Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

Think of what this means to operators of FLOATING ROOF TANKS!

Elimination of potential vapor-loss and preservation of product quality, the most important reasons for a floating roof tank, are now reality . . . the **HAMMOND TUBESEAL,*** for floating roof tanks of welded or riveted construction, provides the most efficient and positive seal known . . . sealed at a point to prevent vapor space between roof, rim and shell, thus there is no room for vapors to form or for the product to come in contact with outside influences and be contaminated . . . the **TUBESEAL*** has no moving parts, requires no maintenance, adjusts for tank out-of-roundness, is climate proof and non-corrodible, can operate to bottom of tank or above the top . . . **ITS ENTIRE CIRCUMFERENCE IS TIGHTLY SEALED UNDER PRESSURE AT ALL TIMES . . . NO VAPOR SPACE BELOW THE SEAL.**



THERE'S NO ROOM FOR VAPORS TO FORM WITH THE HAMMOND TUBESEAL

THE **HAMMOND TUBESEAL*** HAS BEEN THOROUGHLY TESTED IN COMMERCIAL USE . . . IT IS **GUARANTEED** TO YOUR SATISFACTION.

HAMMOND TUBESEAL COSTS NO MORE IN THE FIRST PLACE

*Copyright

ask for Bulletin TS

CHEAPER OVER THE YEARS

HAMMOND IRON WORKS

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CASPER, WYO. • BIRMINGHAM, ALA.

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POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

POWELL LUBRICATED PLUG VALVES

FIG. 3059G—300-Pound Steel Flanged End Valve. Sizes 6" to 12".

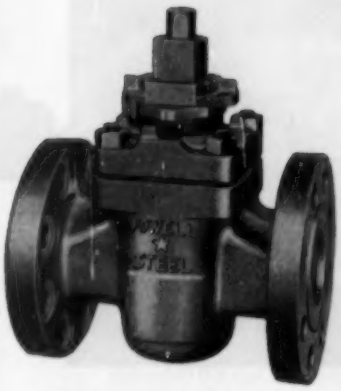


FIG. 1559—150-Pound Steel Flanged End Valve. Sizes 1" to 4".

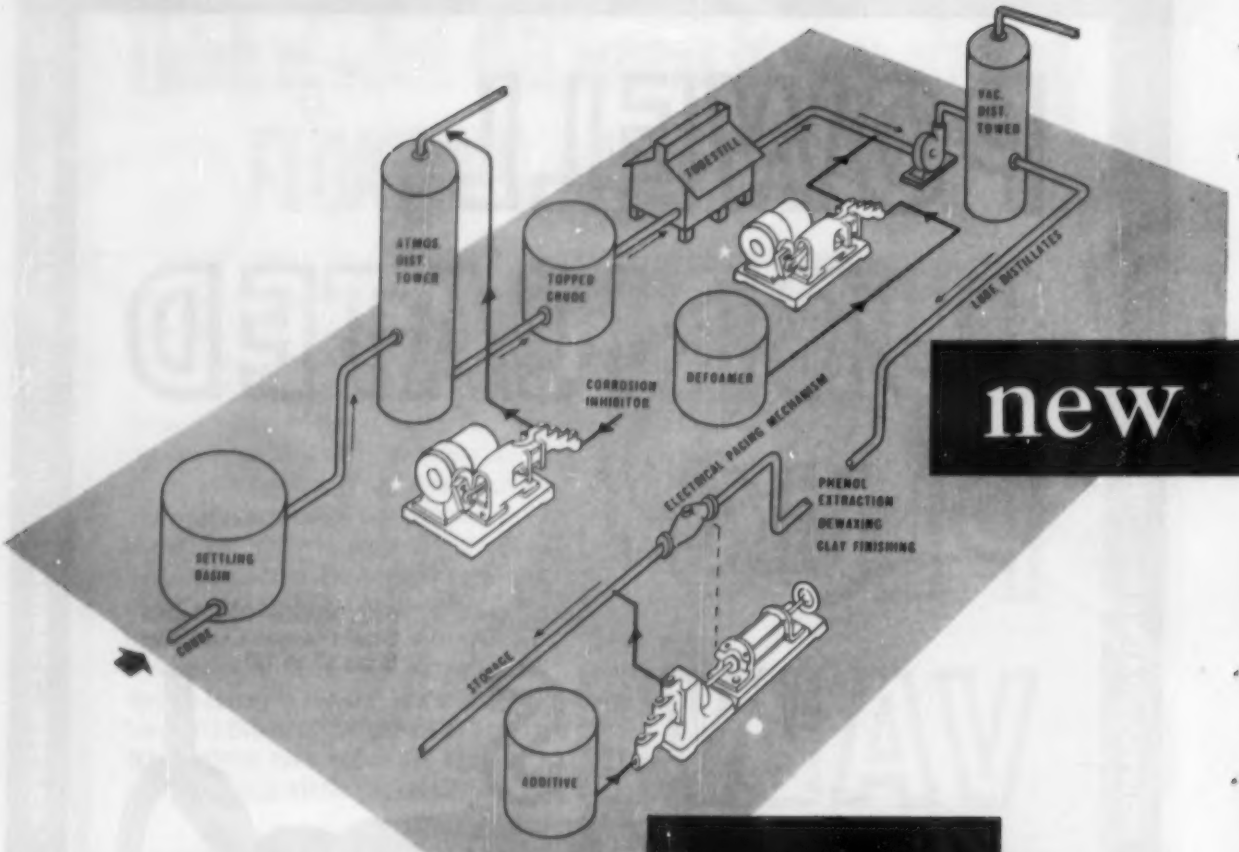
POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

Powell Valves—the *complete* quality line—offer many outstanding features in these new Lubricated Plug Valves, such as quick and sure operation and a positive seal when the valve is closed.

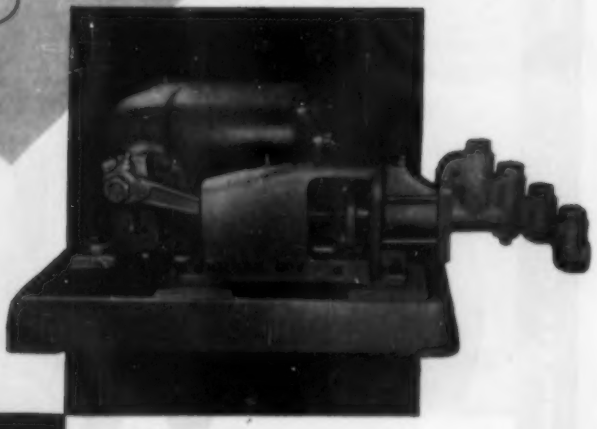
Valves are available with screwed or flanged ends; single, screwed and bolted gland types, and in Semi-Steel, Carbon Steel, Bronze, Ni-Resist, Monel Metal, and Stainless Steel. Semi-Steel valves are rated 175 and 200 pounds W.O.G.; Steel valves, 150 and 300 pounds W.P. Sizes from 1" to 12". Valves in sizes 6" and larger can be furnished with gears for gear operation. Distributors located in principal cities. For descriptive literature—or help on valve problems—write direct to

The Wm. Powell Company, Cincinnati 22, Ohio.....109TH year

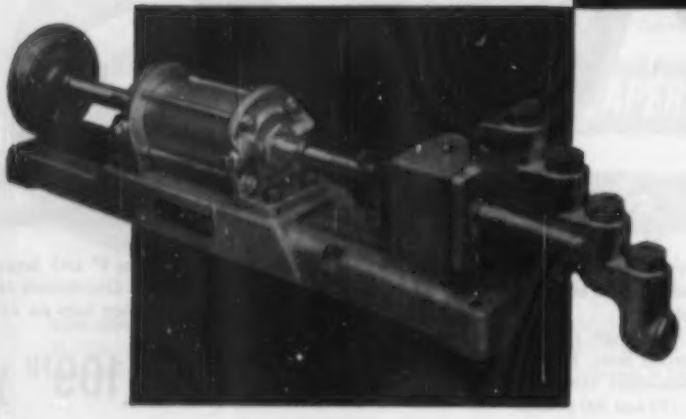
For more data on advertised products, use Readers' Service Cards, last page.



new



○ Air-powered controlled volume pump meters fuel oil additive in precise proportion to main line flow rate.



☆ Standard motor-driven controlled volume pump on corrosion inhibitor feed and defoamer control.

flow-control approach

guards product quality

...cuts chemical costs

Controlled volume pumps are flow control instruments

A NEW approach to low-capacity flow control is making big news in the petroleum processing industry. Additives, inhibitors, octane appreciators, demulsifiers, reagents, and other chemicals are being metered with new accuracy by Milton Roy *controlled volume pumps*. Advantages are many.—More precise flow control. Better quality control. Positive corrosion control. Reduced chemical costs.

Here's why: Controlled volume pumps are actually flow control instruments . . . particularly valuable for low capacity flows. Reciprocating, positive displacement type pumps, they precisely meter process chemicals to an accuracy of within 1%! Exclusive Milton Roy ball-type *step-valve* design assures flow accuracy with volatiles, acids . . . even heavy oils and sludges. Pumps are available in capacities up to 1350 gallons per hour . . . pressures up to 50,000 pounds per square inch . . . with manual or automatic speed and stroke adjustment.

Lube oil processing, left, is only one area in which Milton Roy controlled volume pumps are making flow control news in the petroleum processing industry. Think of all the places they can be applied in your own process! Milton Roy offers you long experience in handling low capacity flow control problems . . . in engineering complete chemical feed and automatic control systems. Write for technical information. Or, send your problem to Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

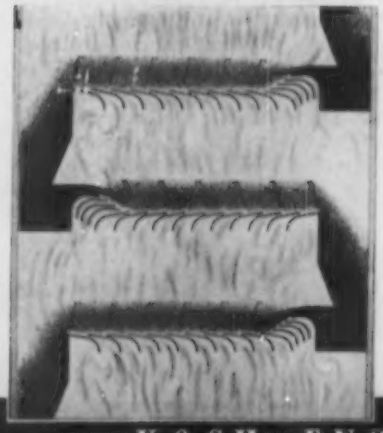
Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, and Africa.

milton Roy
CHEMICAL FEED SYSTEMS

For more data on advertised products, use Readers' Service Cards, last page.

Photo courtesy of Oregon Game Commission

If high liquid volume is your problem



IT WILL PAY YOU TO INVESTIGATE THE HIGHER LIQUID HANDLING CAPACITIES OF KOCH "BENTURI-TYPE" KASKADE TRAYS...THE DIRECTED SLOT ENERGY ACTUALLY ASSISTS THE LIQUID ACROSS THE TRAY.

KOCH ENGINEERING COMPANY, INC.

DESIGNERS • MANUFACTURERS • BUILDERS
321 WEST DOUGLAS • WICHITA 2, KANSAS

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WILFLEY
ACID PUMPS

Cost-Saving Efficiency

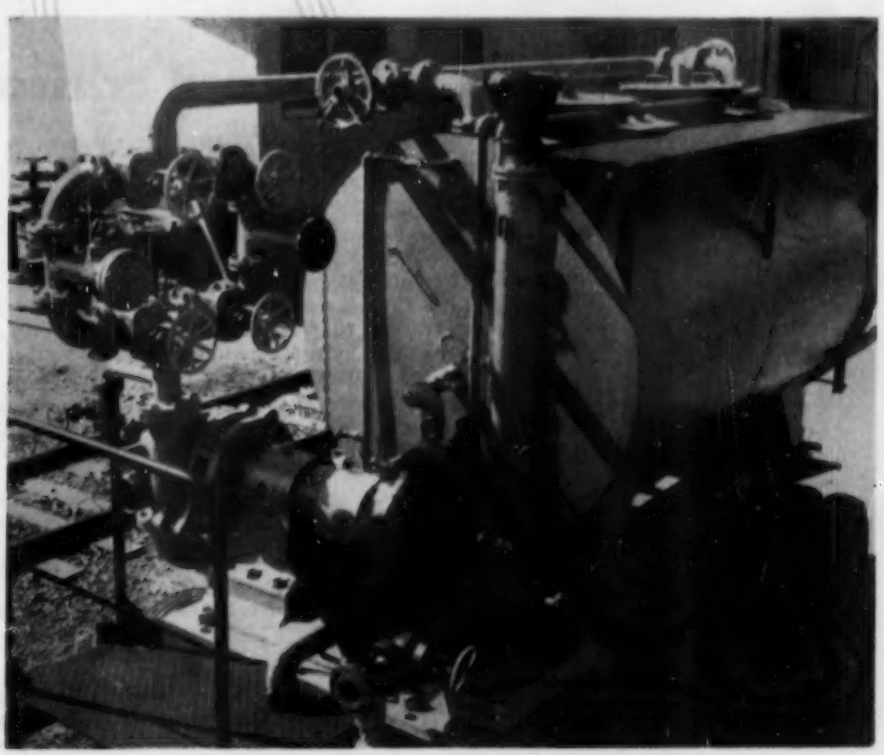
A large west coast refinery uses this Wilfley Acid Pump as part of a portable chemical cleaning unit. Here, as in other modern plants throughout the world, Wilfley Pumps consistently increase production and reduce operating costs. On even the most difficult pumping jobs these dependable, highly efficient pumps deliver continuous, trouble-free performance on 'round-the-clock schedules wherever they are installed. Available with pumping parts of the machinable alloys, as well as plastic, to meet all requirements. Individual engineering on every application. Write, wire or phone for complete details.

Long service life with a minimum of attention.

Economical pump for every requirement.

A. R. WILFLEY & SONS, INC.
Denver, Colorado, U.S.A.

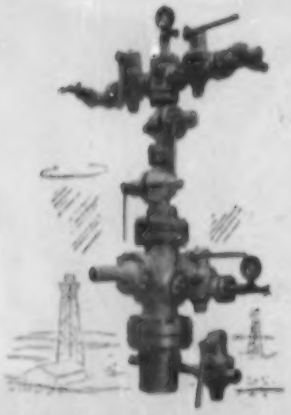
New York Office:
1775 Broadway,
New York City



Wilfley Acid Pump
"COMPANIONS IN ECONOMICAL OPERATION"
Wilfley Sand Pump

Goetze V-Tite Gasket being installed on flange of new Space Saver Blowout Preventer, designed and manufactured by Cameron Iron Works, Inc., Houston, Texas.

Goetze Gaskets safeguard critical points under severe pressures



Christmas Tree made by Cameron Iron Works, Inc., is equipped with Goetze V-Tite gaskets to provide safe, tight sealing for every joint.

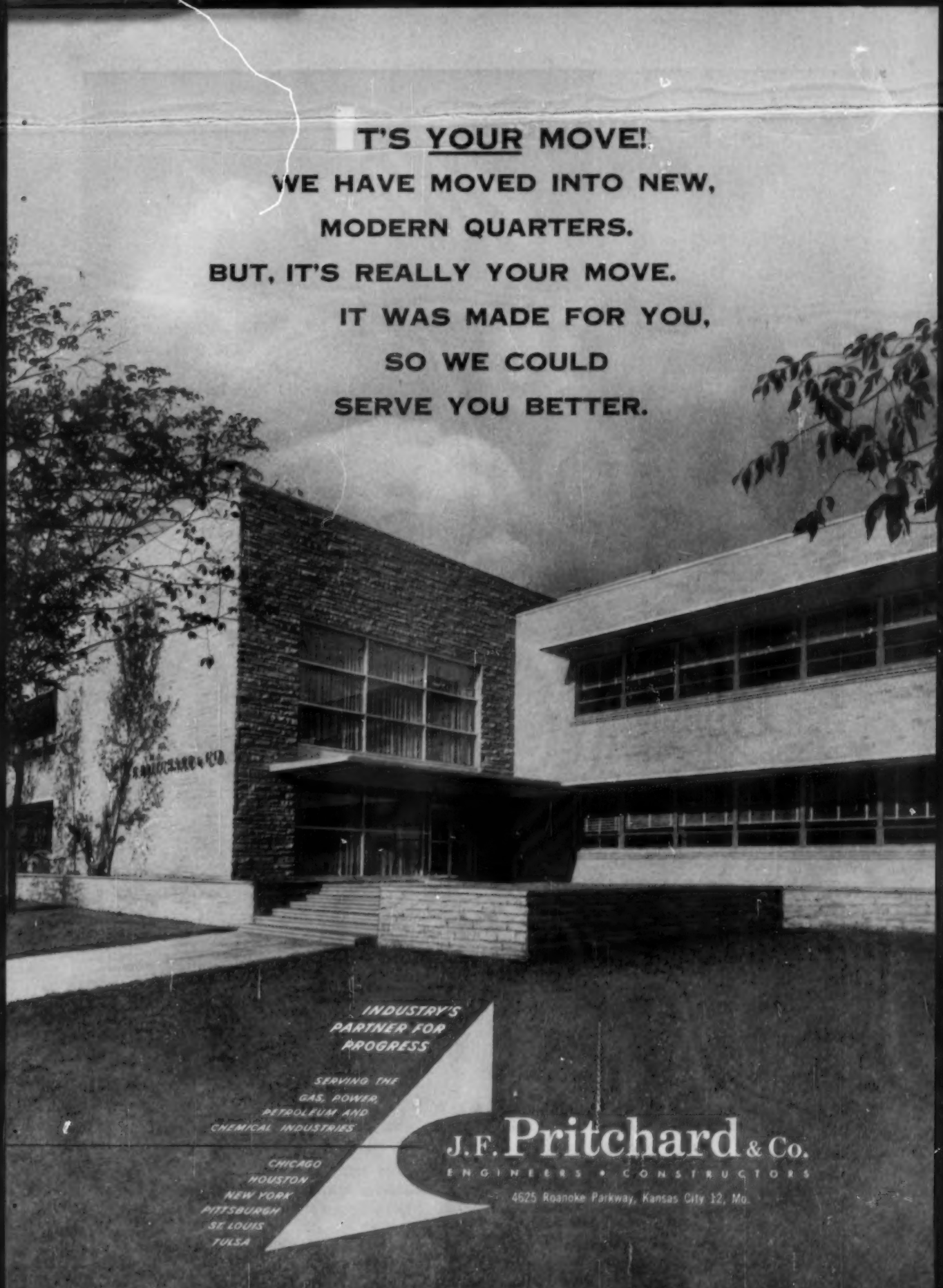
The new "Space Saver" Blowout Preventer made by Cameron Iron Works, Inc., of Houston, Texas, weighs only half as much as earlier equipment and takes only one-half the space. This improved design permits rig platforms to be smaller, makes possible savings on handling and materials.

For this new equipment Cameron chose Goetze V-Tite Gaskets to do the critical job of sealing Ring-Joint flanges. These precision-made gaskets withstand the high pressures encountered in oil and gas production. Goetze V-Tite Gaskets are fabricated to extremely close tolerances to secure perfect matching of rings with flange joints. They are carefully heat-treated to keep hardness below the maximum allowable. This assures proper flow of the gasket without damage to flange surfaces and reduces the necessity for undue bolt stresses.

Both standard cross-sectional shapes, the oval (Style 950) and octagonal (Style 951), seal tightly at low bolt stresses. Made to ASA-API standards, they are supplied in metals and alloys offering maximum resistance to service and temperature conditions. In addition to the ASA-API sizes, special sizes ranging from one inch to seven feet pitch diameter are available. Catalog PK-35A gives details, sizes and engineering data. Write for it to Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

JM PRODUCT

Johns-Manville GOETZE GASKETS


T'S YOUR MOVE!
WE HAVE MOVED INTO NEW,
MODERN QUARTERS.
BUT, IT'S REALLY YOUR MOVE.
IT WAS MADE FOR YOU,
SO WE COULD
SERVE YOU BETTER.
INDUSTRY'S PARTNER FOR PROGRESS
SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES
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HOUSTON
NEW YORK
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ENGINEERS • CONSTRUCTORS
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"Ne Plus Ultra"

OF PROCESS CONTROL

THE *Ultravalve*

Incorporating all the features of special Hammel-Dahl valves used on the most dangerous applications . . .

Now the STANDARD 1000 SERIES of the H-D control valve line.

COMPLETE Information in Bulletin 103-B

HAMMEL-DAHL COMPANY

175 POST ROAD, (WARWICK) PROVIDENCE 5, R. I., U. S. A.

SALES OFFICES IN ALL PRINCIPAL CITIES

MANUFACTURING PLANTS IN WARWICK, R. I., U. S. A., CANADA, ENGLAND, FRANCE AND HOLLAND

CANADIAN MANUFACTURING AFFILIATE—GUELPH ENGINEERING CO., GUELPH, ONT.

ADSCO

EXPANSION JOINTS

ARE MORE EFFICIENT

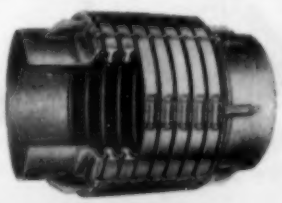
THAN EXPANSION BENDS...

and they cost less

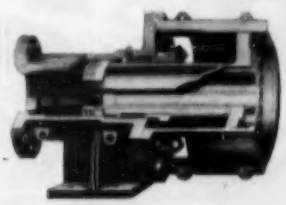
ADSCO Expansion Joints are more efficient than pipe bends for three important reasons:

1. **LESS HEAT LOSS.** A 12-inch line 1000 feet long, carrying steam at 200 lbs. and 550 F, will lose 16% more heat if bends are used instead of ADSCO Expansion Joints.
2. **LESS PRESSURE DROP.** The same line will have a 28% greater pressure drop with bends than with ADSCO Expansion Joints.
3. **LESS SPACE.** One pipe bend requires 100 to 300 sq. ft. of valuable space. An ADSCO Expansion Joint requires little or no extra space.

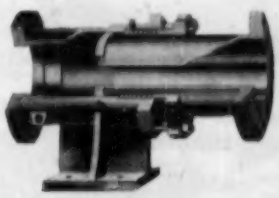
And, in addition, ADSCO Expansion Joints cost less. Used to absorb 4 inches of expansion per 150 feet of 12-inch pipe, an expansion bend, or loop, will cost 50% to 100% more than an ADSCO Expansion Joint. Similar savings can be obtained for other sizes of pipe and for different conditions.



Corruflex Packless Expansion Joint. Requires no maintenance.



Piston-Ring Expansion Joint. Can be unpacked at full operating pressure.



Internally Guided Expansion Joint. Traverses of 4", 8", and 12" per slip.

If you are planning construction of a pipe line, by all means investigate ADSCO Joints. If you already use bends, ADSCO can replace them with joints which will perform better and will still save money.

● *Write for Bulletins 54-10 PR and 35-51 PR*

ADSCO ENGINEERED PRODUCTS

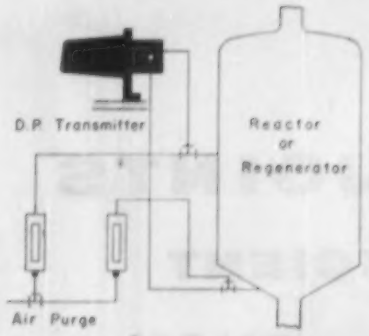
AMERICAN DISTRICT STEAM COMPANY, INC.

GENERAL OFFICES
NORTH TONAWANDA, NEW YORK

PLANTS
NORTH TONAWANDA, N. Y. – RICHMOND, CALIF.

For more data on advertised products, use Readers' Service Cards, last page.

CATALYST LEVEL

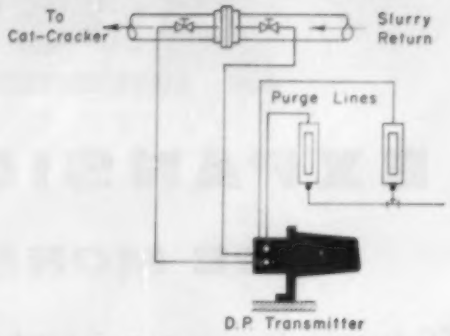


Problem: Sensitive Level Measurement of fluid catalyst in Reactor or Regenerator requiring a range of approximately 600 inches of water, and with a unit having parts common to other process measuring elements.

Solution: Use of a 333RD force-balance differential pressure transmitter with an available range adjustment of 80 to 800 inches of water.

Result: Accurate, Sensitive and Dependable level measurement with complete interchangeability of pneumatic transmitter parts.

AUTOMATIC PURGING OF SUSPENDED SOLIDS

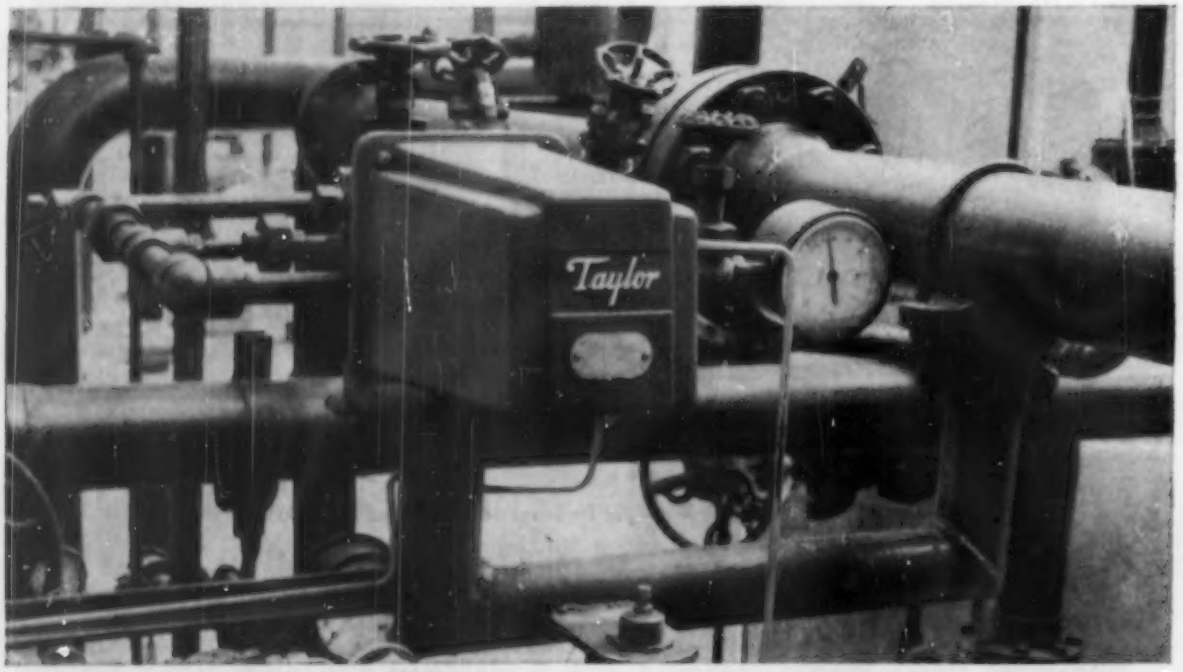


Problem: To obtain uninterrupted flow measurement and control in slurry lines where catalyst solids in suspension can settle out, plugging lead lines and meter, and causing measurement errors.

Solution: Dual body taps provide for purge connections which keep 333RD body, as well as lead lines, completely flushed.

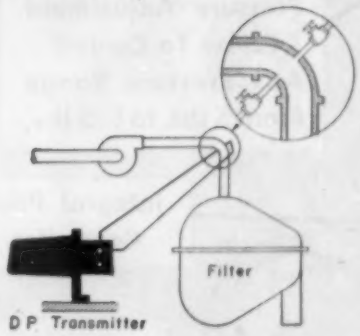
Result: Consistent, dependable high measurement accuracy. Flushing of transmitter body as well as lead lines cuts maintenance to a minimum, especially after shutdown.

A SIMPLE ANSWER TO



One of the TRANSAIRE Flow Transmitters on a reforming unit at Shell Oil Company's Wood River, Illinois, refinery.

SHORT RUNS—REVERSE FLOW—VARYING VISCOSITY

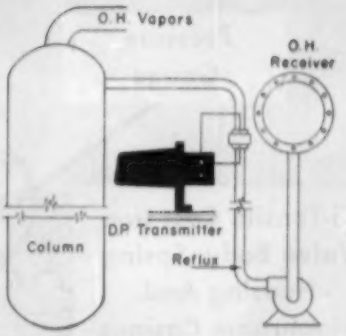


Problem: Dependable flow measurement installation where piping runs are too short for accurate orifice plate installation, the flow is reversed and/or flowing liquid has a varying viscosity.

Solution: The use of the 333RD Transmitter with Elbow Taps as primary elements. Since there is a tendency toward cavitation at the inside tap, the low volumetric displacement of the 333RD makes this type of installation practical.

Result: Accurate measurement and control under any one or more of these three difficult conditions.

WHEREVER A GOOD "WORK HORSE" IS REQUIRED



Problem: To improve flexibility, as well as reduce installation and maintenance costs of conventional flow instruments.

Solution: Standardizing on the 333RD Transmitter. 10-to-1 quick and easy range change; minimum volumetric displacement; may be installed for continuous draining and venting; light weight.

Result: Reduced maintenance cost due to time saved installing, changing of range, and eliminating periodic draining or venting.

DIFFICULT PROBLEMS!

The Taylor TRANSAIRE® Differential Pressure Transmitter (333RD) combines rugged simplicity with remarkable adaptability!

THREE of the applications illustrated above present difficult flow and level measurement problems: the fourth is an every-day installation. In each case the 333RD Transmitter handles the job accurately, dependably and economically.

This very versatile instrument is inexpensive and easy to install, and to maintain; changes in product or seasonal demand cause no problems, due to quick, simple range-change features; it follows flow changes quickly because of low volumetric displacement—has no seal pots.

Some of the features that make it so popular for refinery applications, are:

1. Good overrange protection, due to precisely designed and manufactured back-up plates and use of strong, flexible Teflon-coated glass fabric diaphragm.

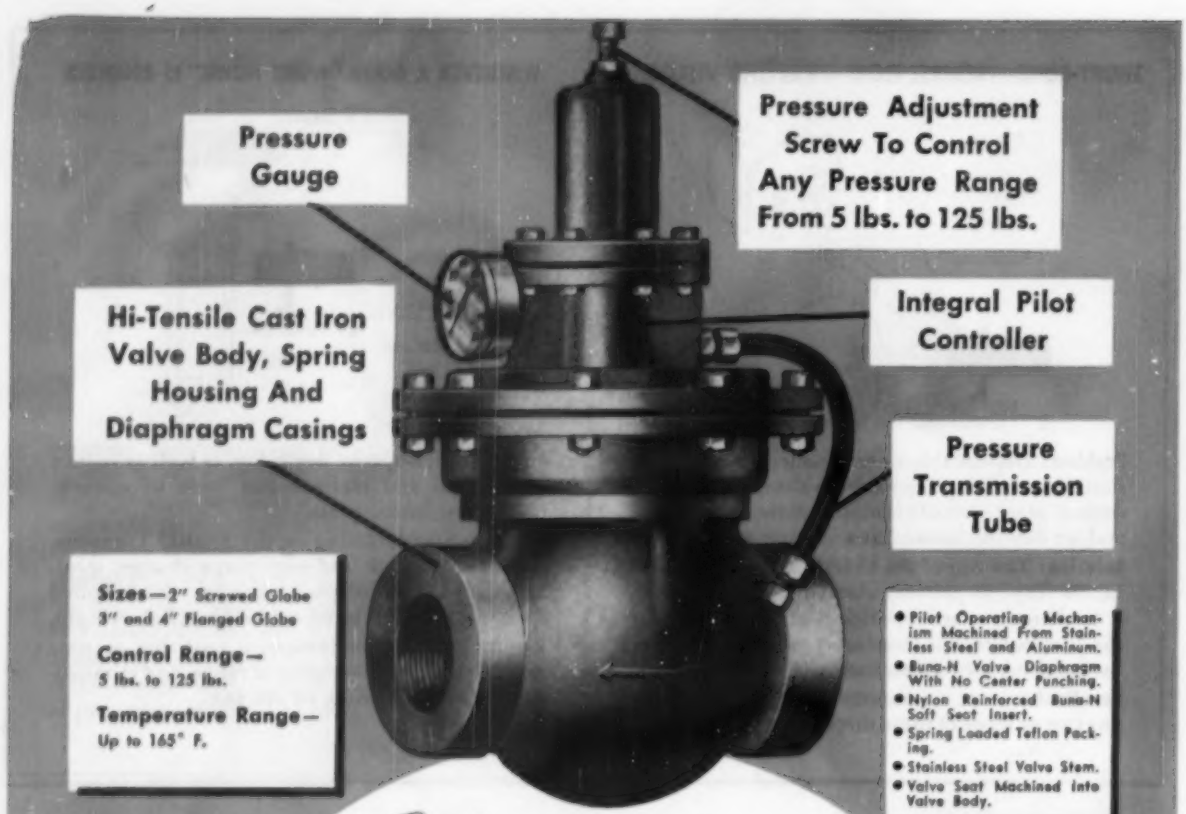
2. Negligible temperature effect resulting from proven design principles and use of low-spring-rate materials.

3. Ease of range suppression by means of an easily accessible, easily adjustable spring.

If you need dependably accurate measurement of flow, liquid level or specific gravity, it will pay you to look into the 333RD. Call your Taylor Field Engineer, or write for **Bulletin 98097.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.


Pressure Gauge
Pressure Adjustment Screw To Control Any Pressure Range From 5 lbs. to 125 lbs.
Hi-Tensile Cast Iron Valve Body, Spring Housing And Diaphragm Casings
Integral Pilot Controller
Pressure Transmission Tube
Sizes—2" Screwed Globe
3" and 4" Flanged Globe
Control Range—
5 lbs. to 125 lbs.
Temperature Range—
Up to 165° F.
• Pilot Operating Mechanism Machined From Stainless Steel and Aluminum.
• Buna-N Valve Diaphragm With No Center Punching.
• Nylon Reinforced Buna-N Soft Seat Insert.
• Spring Loaded Teflon Packing.
• Stainless Steel Valve Stem.
• Valve Seat Machined into Valve Body.

Introducing...

The New BS&B Type 73-22

BACK PRESSURE REGULATOR

...with *Integral Controller!*

Here is the ideal Back Pressure Regulator and valve for services where *close regulation* and *complete closure* are required in a single instrument. Its integral controller provides even closer sensitivity to pressure fluctuations than can be obtained with a weight loaded regulator—yet it has a much wider range of adjustment than is possible with a regulator that depends on direct spring loading.

Designed for optimum control on low pressure oil separators, water knockouts, gunbarrels, gas gathering lines and other equipment requiring close pressure control as well as tight shut-off, the BS&B Type 73-22 also works as well, within its pressure limitations, in all gas or air services that require back pressure regulation.

A feature of this regulator is its ability to operate with the dissipation of a *minimum* quantity of the gas or air used in the controller.

Type 73-22 meets 100% the high standards of *quality* and *performance* for which all BS&B Controls have become so famous throughout the industry. If you'd like more details, write to us direct . . . or ask your BS&B Controls Representative.

Controls Division, Dept. 4-F1
84 Sales Centers 40 Stocking Points

EFFICIENCY OVER 40 YEARS BS&B RELIABILITY

BLACK, SIVALLS & BRYSON, INC.
7500 East 12th Street • Kansas City 26, Missouri

Yes, a Straw Man...Often useful in real estate transactions, he represents the extreme opposite from the help you need for perfect piping when high temperature, high pressure or corrosion is involved. *Remember* to enlist Mitchell "know-how" in prefabricating and erecting . . . and then *forget* your piping.

W. K. MITCHELL & CO., INC.
2946 Ellsworth Street, PHILADELPHIA 46, PA.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

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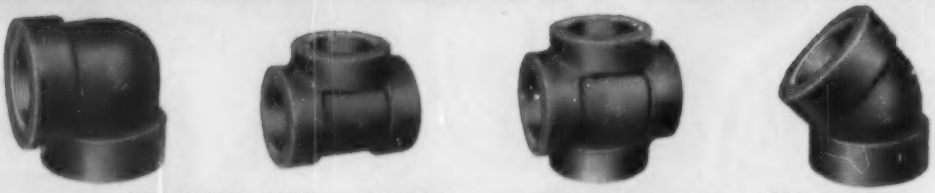
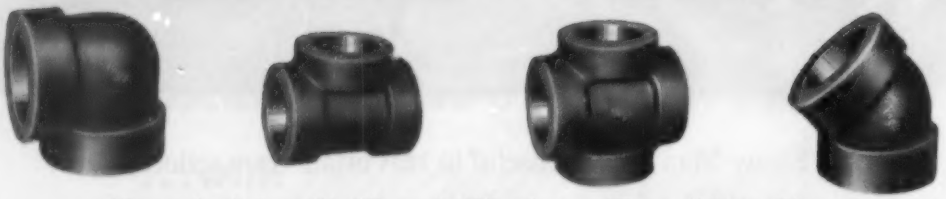
STRENGTH

for Safety and Long-Time Service



For 2000, 3000 and 6000 pounds service — Sizes 1/8" to 6"

SCREW END TYPE



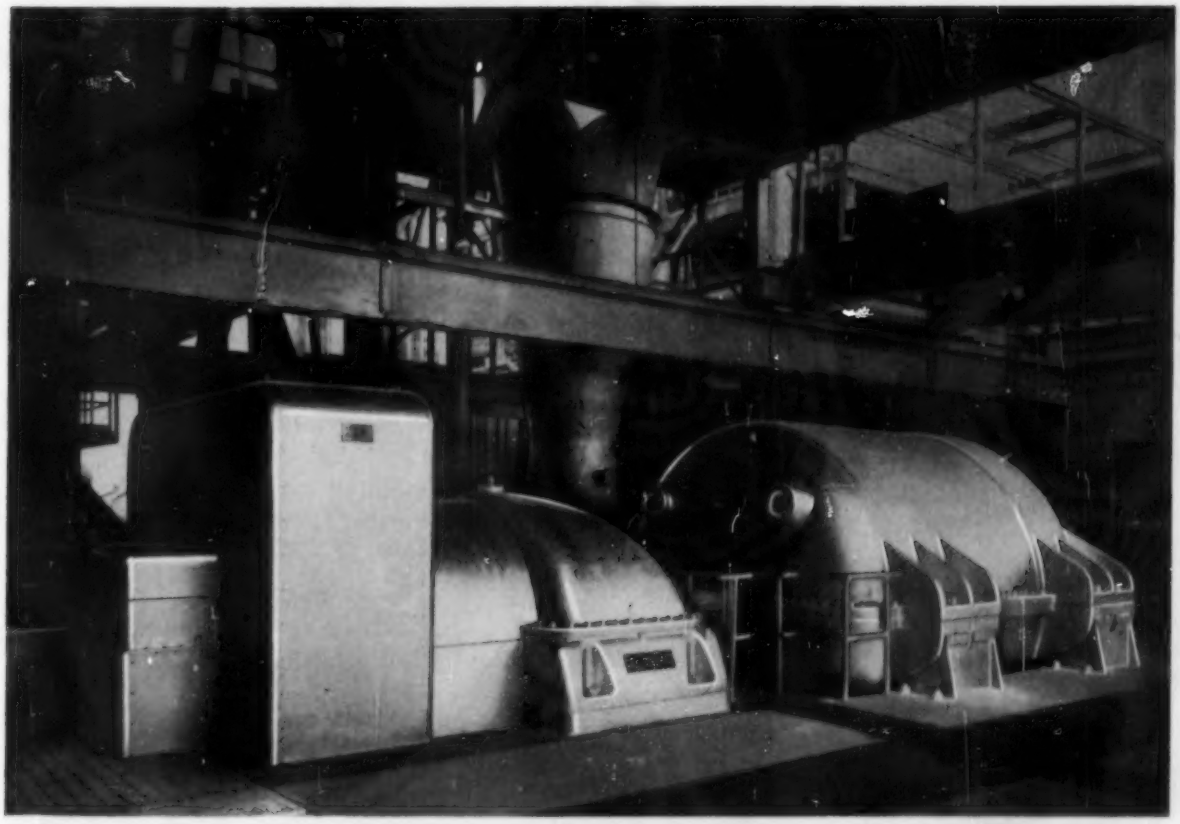
For schedules 40, 80 and 160 pipe — Sizes 1/8" to 4"

SOCKET WELD TYPE

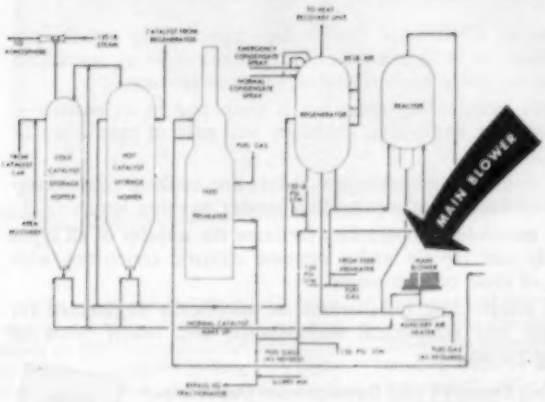
Shocks and stresses imposed by high pressures and high temperatures are taken in their stride because Vogt fittings are uniform in structure, fine grained, and free from porosity . . . the superior product of laboratory controlled materials and giant forging hammers and upsetters. These properties also give higher resistance to erosive and corrosive conditions, thereby adding to service life expectancy in steam plants, petroleum refineries, chemical plants and related industries.

HENRY VOGT MACHINE CO., INC.
Louisville 10, Kentucky
BRANCH OFFICES: NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO • DALLAS

Vogt DROP FORGED STEEL FITTINGS



Largest Centrifugal Compressor for fluid "CAT CRACKER" Service



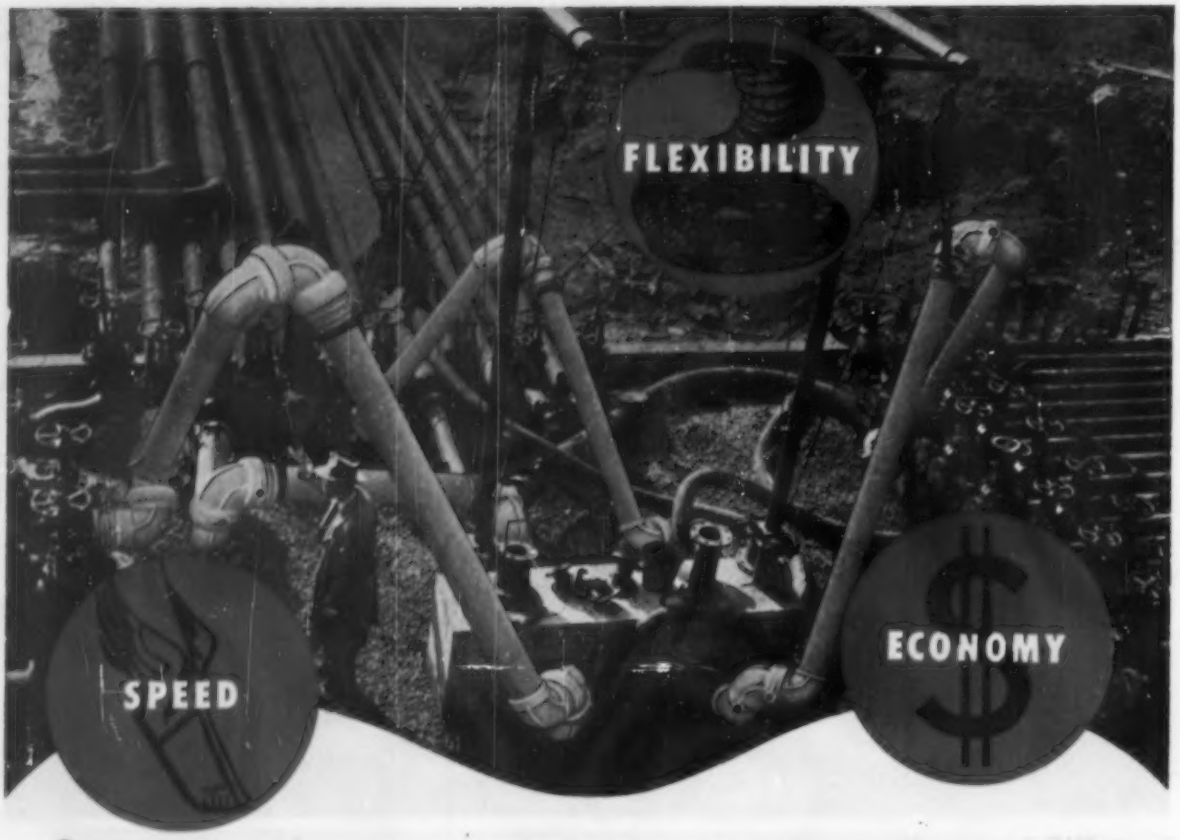
has now been operating about a year in the Sinclair Refining Company's new refinery unit at Houston, Texas. The compressor handles 135,500 inlet cfm of air at 22.0 psig discharge pressure; the turbine develops 12,440 horsepower at 2400 rpm. Complete unit emphasizes ruggedness and accessibility, assuring reliable "non-stop" performance over long periods of time.

Large or small, Elliott can furnish your centrifugal compressor requirements and assure you of equally satisfactory performance. Elliott centrifugal air and gas compressors are serving the petroleum industry throughout the world. Consult your local Elliott office for details or write Elliott Company, Centrifugal Compressor Department, Jeannette, Pa.

ELLIOTT Company

P4-4

TURBINE-GENERATORS TURBINES MOTORS GENERATORS DEAERATING HEATERS EJECTORS CONDENSERS COMPRESSORS TURBOCHARGERS TUBE CLEANERS STRAINERS



CHIKSAN Swivel Joints illustrated in this installation, facilitate the speedy, economical handling of various fluids through 16 lines from loading dock to manifolding pit — a distance of 800 feet. Since each line leads to a separate tank through the manifold, cross contamination is eliminated.

CHIKSAN Swivel Joints in the pump manifold above enable operator to pull base stock from outside storage into the plant and direct flow to proper vessel or proportioner.

The Flow of Enterprise Relies on

CHIKSAN

Ball-Bearing Swivel Joints

CHIKSAN Manifolding Saves 3 Ways!

- ✓ ORIGINAL INSTALLATION
- ✓ NO CONTAMINATION LOSSES
- ✓ LOW COST OPERATION

Original cost of CHIKSAN flexible line manifolding installations often run as much as 50% less than fixed line manifolding operations which incorporate costly multiple valve and line systems.

A CHIKSAN manifolding operation is simplified in its entirety — providing complete flexibility, mobility and ease of operation in limited spaces.

CHIKSAN manifolding installations reduce line hook-up time — keep pit floor clear of lines thereby providing greater working areas.

CHIKSAN manifolding operations facilitate the transfer of all types of fluids safely and rapidly under extreme climatic conditions with no possibility of cross contamination.

CHIKSAN manifolding installations are specifically engineered for long life — easy and economical maintenance, and render years of trouble-free operation.

Our Engineering Research and Development Department will welcome inquiries on your manifolding problems.

Write for Catalog 53-C. Dept. PR-1

CHIKSAN

Representatives in Principal Cities

CHIKSAN COMPANY • BREA, CALIFORNIA • Chicago 38, Illinois • Newark 2, New Jersey

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Chiksan Export Company (Subsidiary), Brea, California • Newark 2, N. J.

• *Stymied by a*
High-Temperature Barrier?

• *Looking for a*
High-Purity Material?

• *Searching for a material with*
Unusual Electrical Characteristics?

You may find the answer in this new booklet on NORTON Refractory Grain

This latest Norton publication is 8½" x 11". Twenty-four pages, with many charts, tables and photographs in color. A wealth of practical information on the nature, performance and application of refractory grains.

IF you're concerned with industrial processing involving temperatures ranging upwards to 4000°C and materials to contain your inferno — if you're looking for a high-purity material such as high-purity fused alumina for coating electronic heater filaments — if you're searching for a material with unusual electrical characteristics such as E 179 CRYSTOLON® Silicon Carbide for lightning arrestors — one of the many types of Norton Refractory Grain available may solve your problem.

This new booklet describes in detail Norton Refractory Grain — produced and purified in electric arc and high temperature resistance furnaces — which is helping industry to improve existing products and processes and to create new ones.

It's a valuable reference book with up-to-the-minute information on the chemical and physical characteristics of such materials as CRYSTOLON® Silicon Carbide, ALUNDUM® Aluminum Oxide, MAGNORITE® Magnesium Oxide, Fused Zirconia and Boron Carbide. In it you'll find data on how these materials are produced; their behavior under varying conditions; available grain size and applications.

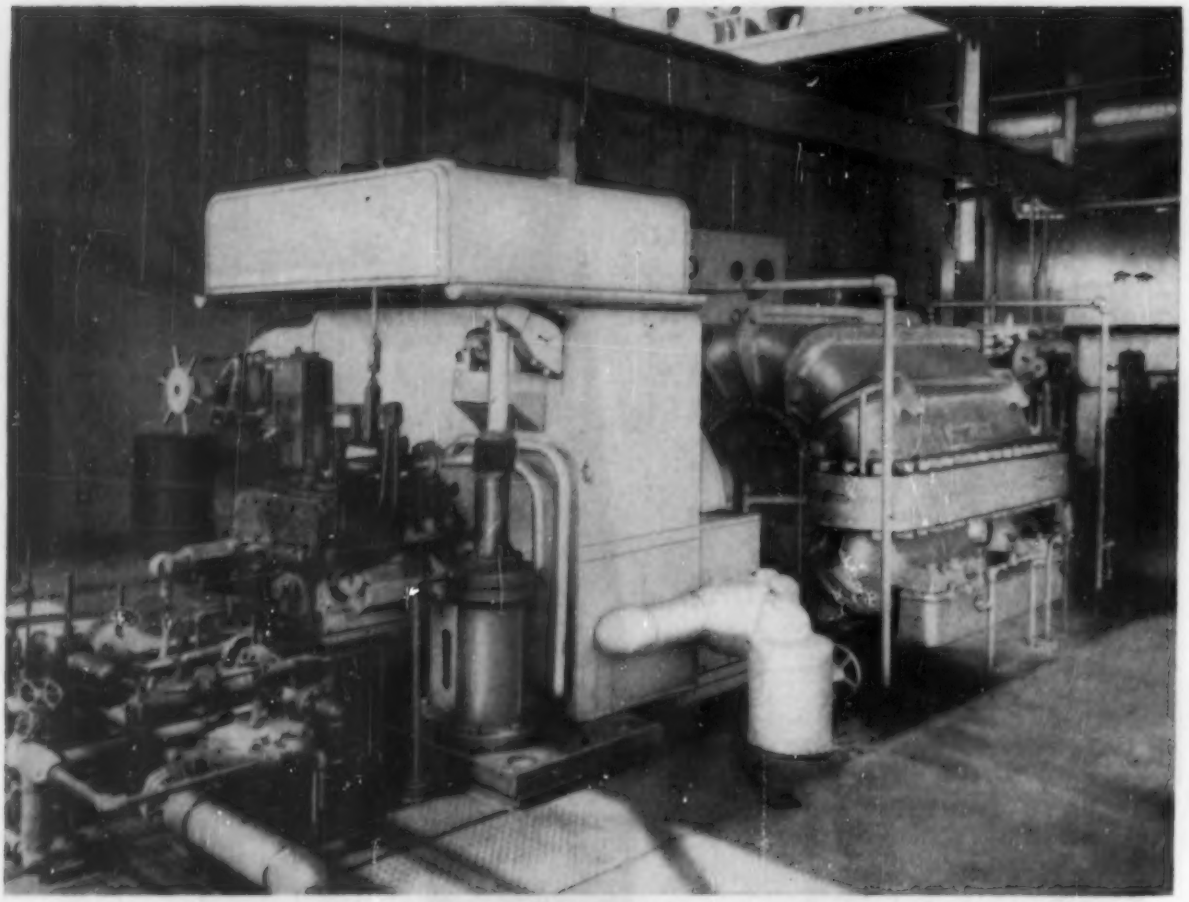
These electrochemically refined materials may be just what you've been looking for to solve your problem. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 460 New Bond Street, Worcester 6, Mass.

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products... to make your products better

®Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

For more data on advertised products, use Readers' Service Cards, last page.



SINCLAIR REFINING COMPANY'S plant in Houston, Texas, gets continuous, dependable driving power for their compressors from high-speed Worthington steam turbines. Other Worthington turbines at Sinclair drive centrifugal pumps.

Worthington high-speed turbines drive compressors around the clock at Sinclair

Twenty-four hours a day, every day of the year. That's the kind of service the Sinclair Refining Company expects — and gets — from their high-speed Worthington turbines.

These Worthingtons have been on stream since 1953, driving centrifugal compressors which compress cracked gas coming from the reactor in a cat cracker.

Like Sinclair, other leading refineries and process plants have found that for continuous, high-speed driving of compressors and blowers, Worthington turbines are the *right* choice.

Remember, the engineering of the drive is just as important as the engineering of the compressor or blower. Worthington's long experience in compressor-drive engineering is your assurance of getting the right type and size drive. Write today for Bulletin 1966 to your nearest Worthington district office, or address Worthington Corporation, Harrison, New Jersey.

T.4.12

SEE the Worthington Corporation Exhibit in New York City. A lively, informative display of product developments for industry, business and the home. Park Avenue and 41st Street.

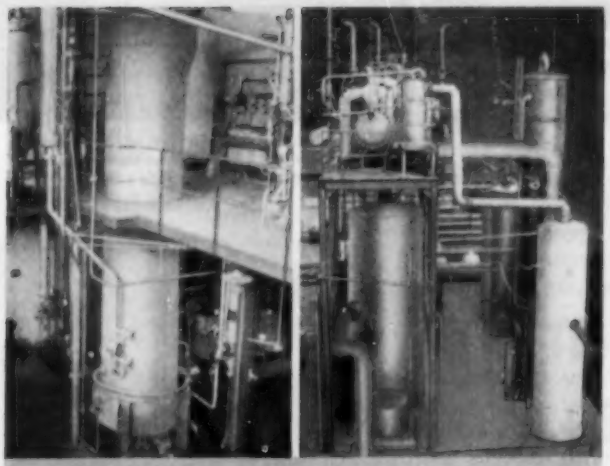
WORTHINGTON

STEAM TURBINES

Single- and Multi-Stage Turbines • Turbine-Generators • Deaerators • Boiler Feed Pumps • Surface Condensers

A GREAT TEAM IN STEAM

product **quality**
process **simplicity...**



Synthesis and recycle sections of the Havag Urea Plant, Ems, Switzerland.

these are reasons why the **Inventa** process for

UREA

is gaining increased recognition...

More and more, attention is being turned to Vulcan Engineering and the Inventa Urea Process. Now the vast potentialities of urea production—for fertilizers, cattle feeds, plastics, pharmaceuticals—can be fully realized. For here is a process which produces *only* top-quality product, suitable for all these applications—and with minimum plant investment.

- The Inventa Urea Process has been thoroughly tested and *proven* in nearly six years' tonnage production
- A basically *simple* process, it attains high per-pass conversion of ammonia to urea—*without the use of diluents.*
- Commercial operation of the Inventa Urea Process has *demonstrated* a remarkably low level of plant maintenance. This stems from a combination of special materials of construction and operating techniques.
- This all adds up to low initial outlay and long-term operating economy—*plus* the year-around saleability of an all-purpose product!

Engineering and procurement by Vulcan for two major plants utilizing this process are currently in progress. When your company considers urea production let Vulcan Engineering furnish you with more details concerning this valuable process.

VULCAN ENGINEERING DIVISION

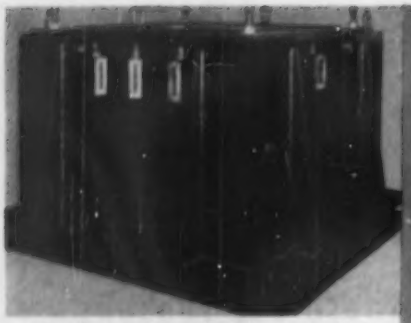
The VULCAN COPPER & SUPPLY CO., *General Offices and Plant,* CINCINNATI 2, OHIO

NEW YORK BOSTON HOUSTON SAN FRANCISCO

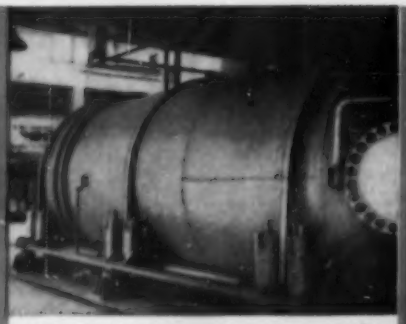
VICKERS VULCAN PROCESS ENGINEERING CO., LTD., MONTREAL, CANADA

DIVISIONS OF THE VULCAN COPPER & SUPPLY CO.:

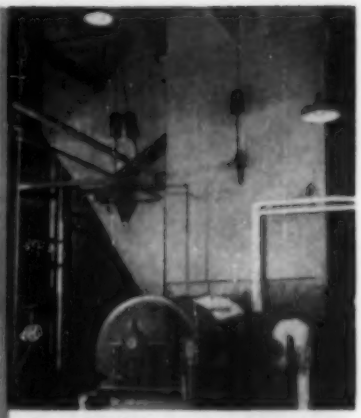
VULCAN ENGINEERING DIVISION • VULCAN MANUFACTURING DIVISION • VULCAN CONSTRUCTION DIVISION • VULCAN INDUSTRIAL SUPPLY DIVISION



Base for supporting refinery tower, provided with Grinnell Spring Hangers for flexible support.



Grinnell Spring Hangers on large vessel of catalytic cracking unit in oil refinery.



Induced draft duct and blower in power station. Operates at about 500°F. Supported by Grinnell Spring Hangers.

To support loads that won't stand still . . .

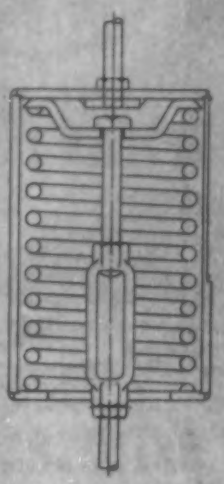
GRINNELL PRE-ENGINEERED SPRING HANGERS

There are many industrial installations where heavy loads must be firmly, but flexibly, supported to keep them under control. Thermal expansion and contraction, of course, can move ponderous objects many inches. Shock and vibration, too, can make rigid support of heavy loads hazardous, due to possible serious trouble at terminals.

For installations such as these, more and more engineers are turning to *flexible* supports by Grinnell. Grinnell Variable Spring Hangers are *pre-engineered* to minimize changes in supporting force over total range of movement. Here are the important features that let these units turn in a star performance in a supporting role:

- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- Solid steel casing protects spring from damage and weather. Guides assure continuous alignment and concentric loading of spring.
- 18 sizes available from stock — load ranges from 53 lbs. to 12,000 lbs.
- Easy selection of proper sizes from simple capacity table.
- Installation is simplified by integral load scale and travel indicators.

*Precompression is a patented feature.



VARIABLE SPRING HANGER FIG. B-268

Fig. B-268, Type A, is designed for attachment to its supporting member by screwing a rod into a bushing in the top cap of the hanger. Adjustment of the hanger load is accomplished by turning the turnbuckle on the lower hanger rod until the hanger picks up the load and the load indicator points to the desired position. Six other types of attachment are available.

Grinnell Variable Spring Hangers are also available in half sizes (Fig. B-82); and in double spring sizes (Fig. B-98).

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPLIERS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
Industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

a valve that never blows its top

All K & M diaphragm Control Valves have a drawn steel diaphragm casing able to withstand extreme heat, impact, pressure and shock . . . and a cast steel open yoke that retains its strength when the heat is on. When something goes wrong, the difference between safety and danger might very well be this all steel construction.

Further, consider the everyday advantages of the all steel K & M construction: One man can move the smaller size valves without hoists, for the K & M steel topworks weighs only half as much as other topworks of equal size. The open yoke, provided in cast steel by *only* K & M, assures accessibility and completely eliminates any possible accumulation of gas, vapor or condensate.

More linear . . . more accurate . . . more responsive

The K & M molded neoprene diaphragm provides a large effective area which is constant throughout the long stem travel. Thus, K & M Diaphragm Motors provide maximum linearity in stem movement and virtually the highest power factor available. Operating with high capacity, low turbulence K & M valve bodies, these motors mean more accurate, more responsive flow regulation.

For Complete Automatic Control Valve Data: Write for your copy of the new K & M Valve Engineering Data Catalog, Bulletin CV53. *Also Available . . . New* Valve Size Calculator with Low Flow Data.

diaphragm control valves

KIELEY & MUELLER, INC.

K&M

Valve Makers
Since 1879

64 Genung Street
Middletown, New York

H-1515

U. S. Amazon

MOST AMAZING development in the history of oil discharge hose!

There is no other hose on the market that can match H-1515's contribution to oil transportation.

HERE ARE THE FACTS:

1. Weighs 2/3 less than conventional hose.
2. End fittings weigh 50% less.
3. Used by every major oil company. It has been tried and proven by up to 3 years' service.
4. More than 800 lengths of U. S. Amazon H-1515 now in service.
5. Its light weight eliminates accidents that occur with the handling of heavy hose.
6. Requires less manpower or mechanical handling devices to make connections for loading or unloading.
7. Instantly springs back to shape if crushed or folded.
8. It handles 200 pounds working pressure.
9. Dock workers are outspoken in praise of its lightness and ease of handling.
10. It is indispensable for hard-to-reach bunkering headers. Connections are made without the use of a hoist.
11. No further proof or trial is required to establish its superiority.
12. Easily transported—can be coiled or folded on truck or other vehicle for moving between locations.

More than 800 lengths of U. S. Amazon® H-1515 Oil Discharge Hose have been put into active service from coast to coast in the short space of 3 years—the superiority of this great hose has been proven and accepted beyond question. U. S. Amazon H-1515 is made only by United States Rubber Company and sold through any one of the 27 "U. S." District Sales Offices. Further information is obtainable by writing the address below.

"U. S." Research perfects it.
"U. S." Production builds it.
U. S. Industry depends on it.

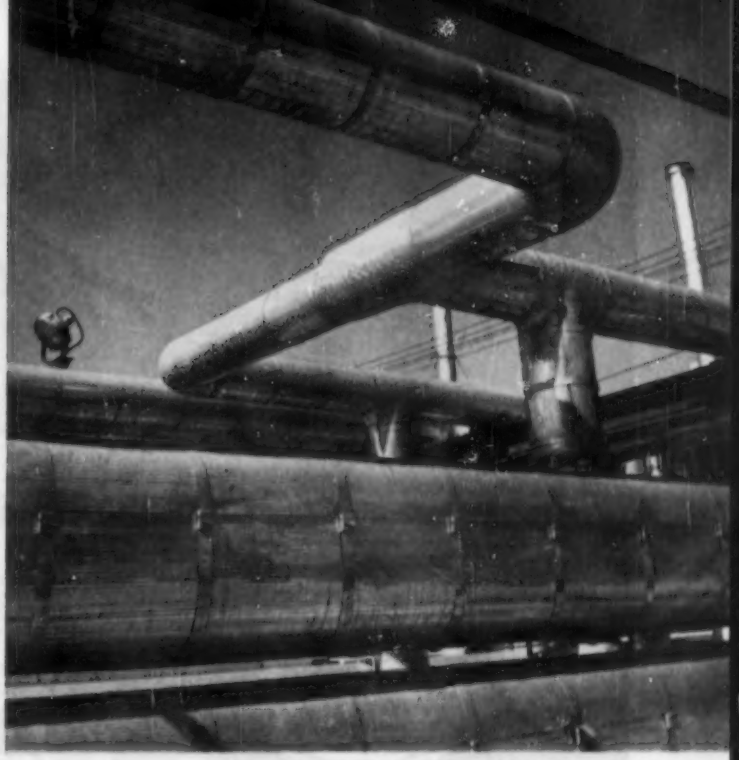
US RUBBER

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

How Olin Mathieson Uses Childers Jacketing For Insulated Lines

Jacketing problems at new plant ranged from covering tall towers to irregularly-shaped heat exchangers. Read how aluminum jacketing solved these problems.



More than 244,000 square feet of Childers .006" Jacketing and 35,000 square feet of heavy weight Childers Jacketing was used in this new Olin Mathieson plant to weather-proof insulated lines, towers and vessels. Close-up above shows how aluminum jacketing was applied with strapping and seals.

Low first-cost, long life, and easy installation were the big reasons Olin Mathieson Chemical Corporation used Childers Aluminum Jacketing for outdoor insulated lines in their new Brandenburg, Ky., petrochemical plant.

Mathieson used Childers standard weight Jacketing on their insulated lines. Heavier weights of Childers Jacketing were used on high towers and vessels where a stiffer material was needed to support the vertical weight of the jacketing.

Engineers report that Childers Jacketing is inexpensive to apply. It comes in easy-to-handle rolls 4 ft. wide and 100 ft. long. Just pliers and a pocketknife are the only tools needed to apply. And because the jacketing is aluminum it needs no painting . . . stays clean and new looking even after years of service.

Childers Jacketing is easily removable, too. Just remove the strapping and jacketing can be taken off for inspection of the lines. Then same jacketing can easily be put back on the insulated line.

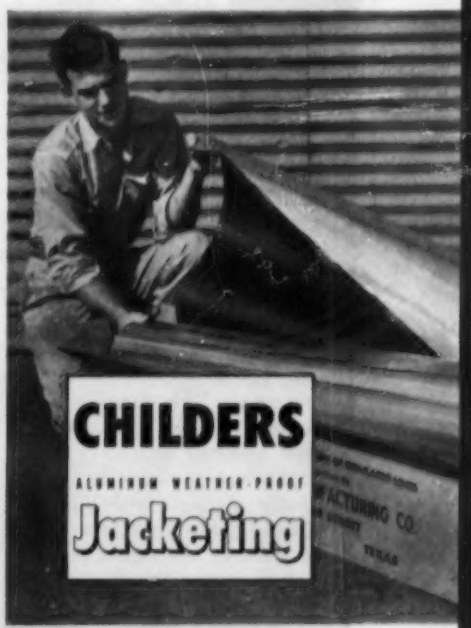
Immediate shipment from our large factory stocks can eliminate costly delays in construction or plant improvement schedules.

Try this low-cost protection in your plant. Write today for engineering data and information. You can order a 400 sq. ft. roll to test on one of your insulated lines. No obligation. Address: Childers Manufacturing Company, Department PR-24, 3620 West 11th St., Houston, Texas.

How to apply Childers Jacketing:

1. Best method of attaching jacketing is aluminum strapping and seals. Strapping can be pulled plenty tight with pliers like this. Other method is to use sheet metal screws.

2. A two-man crew can apply jacketing fastest. No special shop work or roll forming is necessary. Only tools needed are a pliers and a screw-driver or wooden wedge.



Each roll of Childers Jacketing comes individually packed like this in a heavy corrugated carton. Rolls are 4 ft. wide. With moisture barrier attached they are 100 ft. long; without moisture barrier they are 200 ft. long. They are well protected for field storage if kept dry. Individual boxes are light enough for one man to handle. (Adv.)

announcing the NEW

STRONG Hydro-Flex STEAM TRAPS

FOR LOW AND HIGH PRESSURE SERVICES TO 2500 PSI and 1100° F

GREATER CAPACITY

LOWEST MAINTENANCE

UNMATCHED OPERATION ON LIGHT LOADS

Here's a new standard of performance in steam traps —Strong "Hydro-Flex"!

This completely new line of low, medium and high pressure steam traps combines high discharge capacity with high efficiency under all condensate loads. This built-in flexibility can mean lower steam and maintenance costs plus higher production.

Strong "Hydro-Flex" meets the need for a trap that operates efficiently on light condensate loads. Under normal plant conditions many traps actually function at less than 1% of rated capacity. Strong's "Hydro-Flex" design makes possible high discharge rates when required, yet assures unequalled performance on low loads. This new concept in steam traps is the product of five years of development work and 50 years of steam trap experience.

Take advantage of this new, better standard of steam trap economy—standardize on Strong "Hydro-Flex". For complete details, contact your local Strong distributor or write for new Catalog No. SS-40.

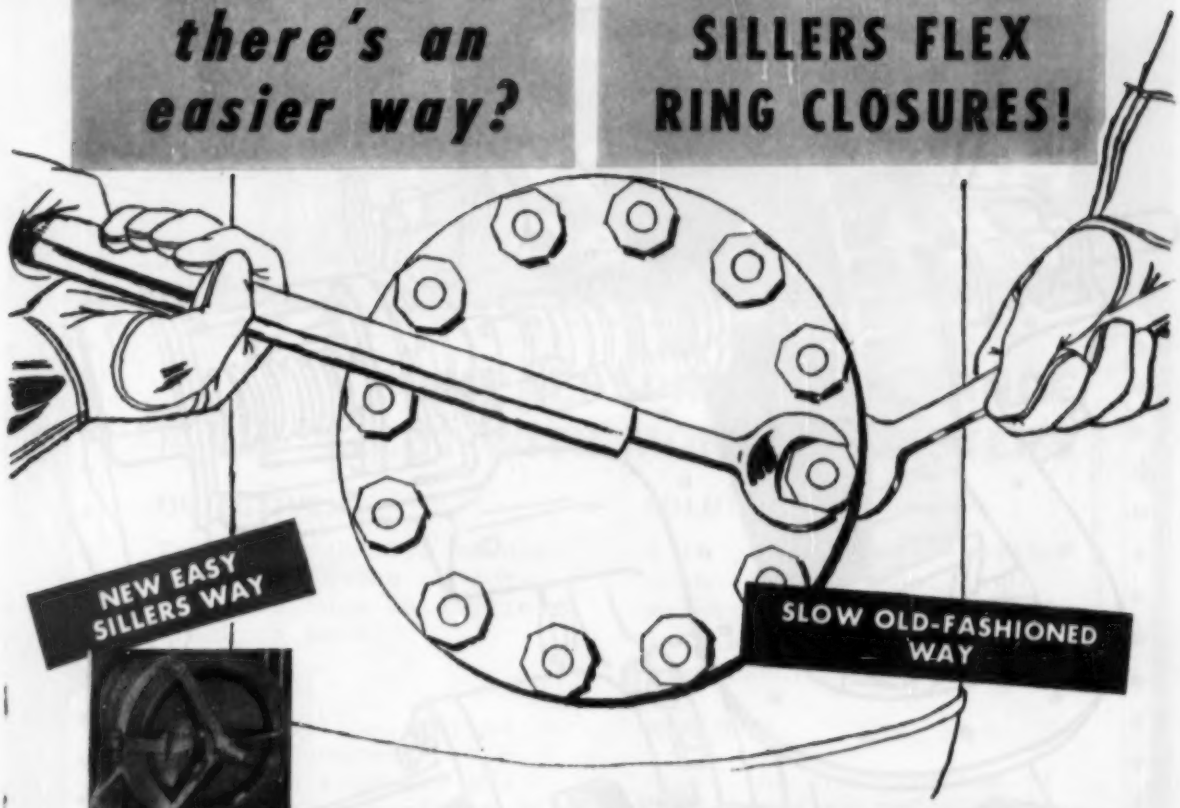
STRONG, CARLISLE & HAMMOND CO.
1968 WEST 3rd STREET · CLEVELAND 13, OHIO

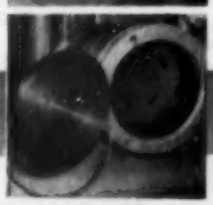
STRONG HYDRO-FLEX STEAM TRAPS high efficiency under all condensate loads

Available from over 200 industrial distributors in the United States, Canada and foreign countries.

Did you say there's an easier way?

SURE! SILLERS FLEX RING CLOSURES!





(1). Flex Ring Unit assembled as in service. (2). Spider released, gasket being removed. (3). After gasket is removed, plug is rotated to open. (4). Unit completely opened and in a fraction of time taken for conventional type closures.

Now . . . new SILLERS FLEX RING CLOSURES give easier, faster access to insides of pressure vessels and piping systems than was ever before possible. Incorporating an entirely new design and seal principle, the SILLERS FLEX RING CLOSURE gives you many advantages and economies such as low initial cost . . . less time in opening and closing . . . tighter seal at high pressures . . . less weight . . . and ease in handling. SILLERS FLEX RING CLOSURES are available in all standard sizes and quickly can be adapted for special applications.

WRITE TODAY FOR SILLERS'S BULLETIN NO. 3,000 FOR COMPLETE DETAILS ON NEW SILLERS FLEX RING CLOSURES.

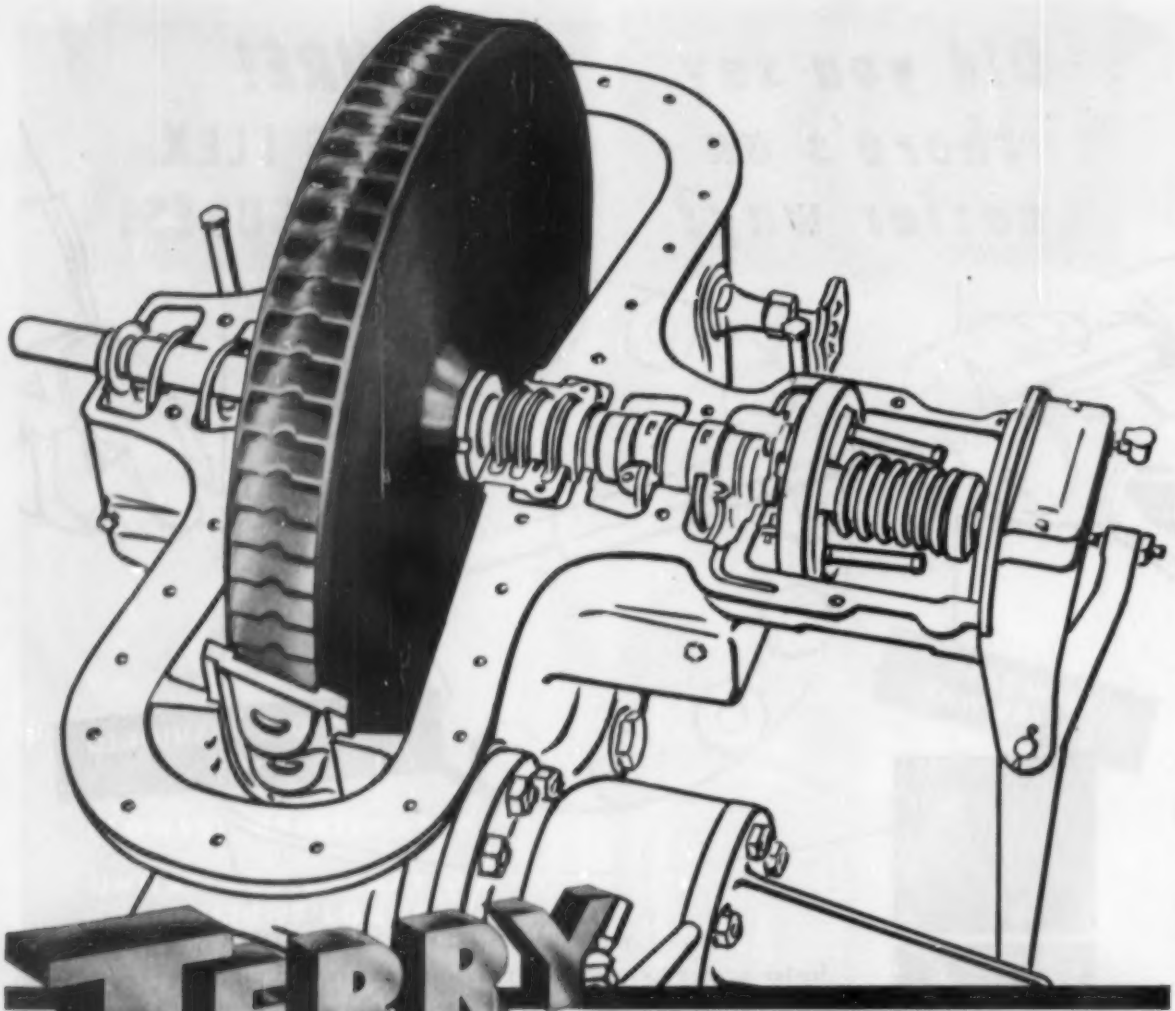
SILLERS ENGINEERING COMPANY

Division of Peerless Manufacturing Company

BOX 13165 • DALLAS, TEXAS

Representatives in Principal Cities

For more data on advertised products, use Readers' Service Cards, last page.



SOLID WHEEL RUGGEDNESS

is your turbine dividend

The rugged construction and fool-proof design of a Terry solid-wheel turbine can save you money by keeping maintenance costs to a minimum. Usually only taken down for routine inspection, any repairs that must be made are of relatively simple nature, and cost of replacement parts is small.

The rotor of the turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which might occur would not materially affect horsepower or efficiency.

It is impossible for the blades to foul. They have large clearances and are further protected by the projecting rims of the sides of the wheel. As the side clearances are also very large, end play can do no harm.

The Terry solid-wheel turbine is an extremely reliable piece of equipment—why not write for complete details today? Ask for a copy of Bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TT-1198

INCREASE throughput capacity
ELIMINATE costly liquid loss
IMPROVE overhead product quality
REDUCE harmful air pollution
with

YORKMESH DeMISTERS

CASE STUDY
No. 1006

COMPRESSOR MAINTENANCE CUT WITH MONEL DEMISTERS

OBJECTIVE:

To stop excessive maintenance shutdowns of compressors on a catalytic cracking unit.

PROBLEM:

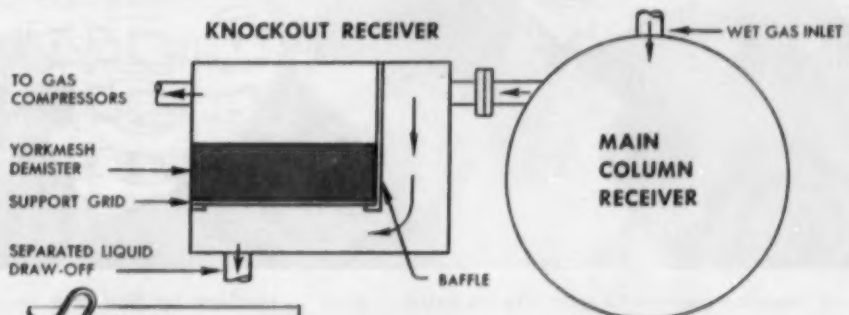
Heavy gasoline carried into the compressors diluted the lube oil and coated valve surfaces with a soft coke-like material. Valve life was thirty days or less.

SOLUTION:

A 12" thick monel demister mounted on a monel light weight grid was installed in a knock-out box in the compressor suction line.

RESULTS:

Since the installation of this demister pad the compressors have run more than a year without extra maintenance.



Note: For the full story of how monel demisters cut compressor maintenance write for case study #1006.

YORK

OTTO H. YORK CO., INC.
6 CENTRAL AVE. • WEST ORANGE, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

He helps teachers in 54,000 classrooms

Radio was barely out of the earphone stage 26 years ago when a new program was beamed from a San Francisco studio. It featured a string trio and was based on the idea that good music, when clearly understood, could entertain and teach, too. Actually, only 72 Western schools had radio sets then, but with that performance the Standard School Broadcast was "on the air."

Today, when Conductor Carmen Dragon lifts his baton, it's "time for the Standard School Broadcast" in over 54,000 classrooms through the West, Alaska and Hawaii. Counting children, teachers and home listeners, the program reaches a weekly audience of nearly 1½ million. That string trio has grown to a symphonic orchestra with a dramatic cast, choral group and guest vocal and instrumental artists. Selections range the musical alphabet from symphony to jazz. Each year's course follows a carefully planned outline published in a manual supplied to teachers by Standard to serve as a guide in blending music-enjoyment with subjects like art, literature, social studies. Now in its 27th year, the Standard School Broadcast is radio's oldest education program, heard today over more than 100 stations. Its goal is to help Western children gain an absorbing new interest in the world's good music, and —through music—a broader knowledge and understanding of the world around them.

Listen to the Standard School Broadcast every Thursday. Check your newspaper radio log for the time and station.

STANDARD OIL COMPANY OF CALIFORNIA

75 years of planning ahead to serve you better

only MASTER offers you a choice

DYNAMIC UNIBRAKE MOTORS

In Master Type D Unibrakes, dynamic braking is obtained with a unique, patented brake winding superimposed on the stator winding of any Master single phase or polyphase AC induction motor. This provides dynamic braking for AC motors with no outside source of DC current required.

ADVANTAGES. Type D, Dynamic Unibrakes are very simple and compact, and as the brake has no moving parts, there is nothing to wear . . . nothing to adjust . . . braking torque remains uniform.

SIZES. Now available up to 30 horsepower . . . larger ratings are being developed. Master Gearmotors and variable speed drives can also be supplied with Type D Unibrakes.

MAGNETIC UNIBRAKE MOTORS

Type M Unibrakes have electro-magnetic brakes of the friction disc type built into a continuation of the motor end cover, on the end opposite the regular shaft projection. Electric brake and motor form a compact, integral unit.

ADVANTAGES. Type M Unibrakes are ideal for applications where quick or controlled stopping is required. They are particularly desirable on such applications as elevators, hoists, inclined conveyors, etc. where it is necessary to hold the load.

SIZES. Available from ⅛ to 150 horsepower and for practically any type Master motor. Master Gearmotors and variable speed drives can also be supplied with Type M Unibrakes.

OIL INDUSTRY TECHNOLOGISTS, investigating methods of

LUBRICATE PLUG VALVES

in seconds — instead of minutes

with this timesaving combination

Yes, seconds are all it takes to lubricate plug valves, today. You'll eliminate waste, and save time and effort with this combination: Walworth High Pressure Lubricant Gun, Walworth Button-Head Fittings, and Walworth Jumbo Size Lubricant Sticks. They'll pay for themselves quickly and are adaptable to most of the lubricated plug valves that are in use today.

Walworth High Pressure Lubricant Gun. This is the only gun available today that satisfactorily handles the stick form, full-bodied lubricants needed for proper lubrication and sealing of plug valves. Easy to operate; two Jumbo Size Lubricant Sticks fill the barrel.

Walworth Button-Head Lubricant Fittings. Use them as lubricant fittings or as regular lubricant screws with standard size lubricant sticks. Just slip hose coupling onto fitting for a leakproof connection.

Walworth Jumbo Size Lubricant Sticks. Individually wrapped and packed ten to the box; clean and easy to handle . . . eliminate messy loading. Types available for most line fluids. Always use Walworth Lubricants in Walworth Lubricated Plug Valves.

Start saving today . . . call your nearby Walworth Distributor. He'll be glad to supply Walworth High Pressure Lubricant Guns, Button-Head Fittings, and the right Jumbo Size Lubricant Sticks for any lubricated plug valve service condition.

WALWORTH

Manufacturers since 1842

valves . . . pipe fittings . . . pipe wrenches

60 East 42nd Street, New York 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

For more data on advertised products, use Readers' Service Cards, last page.

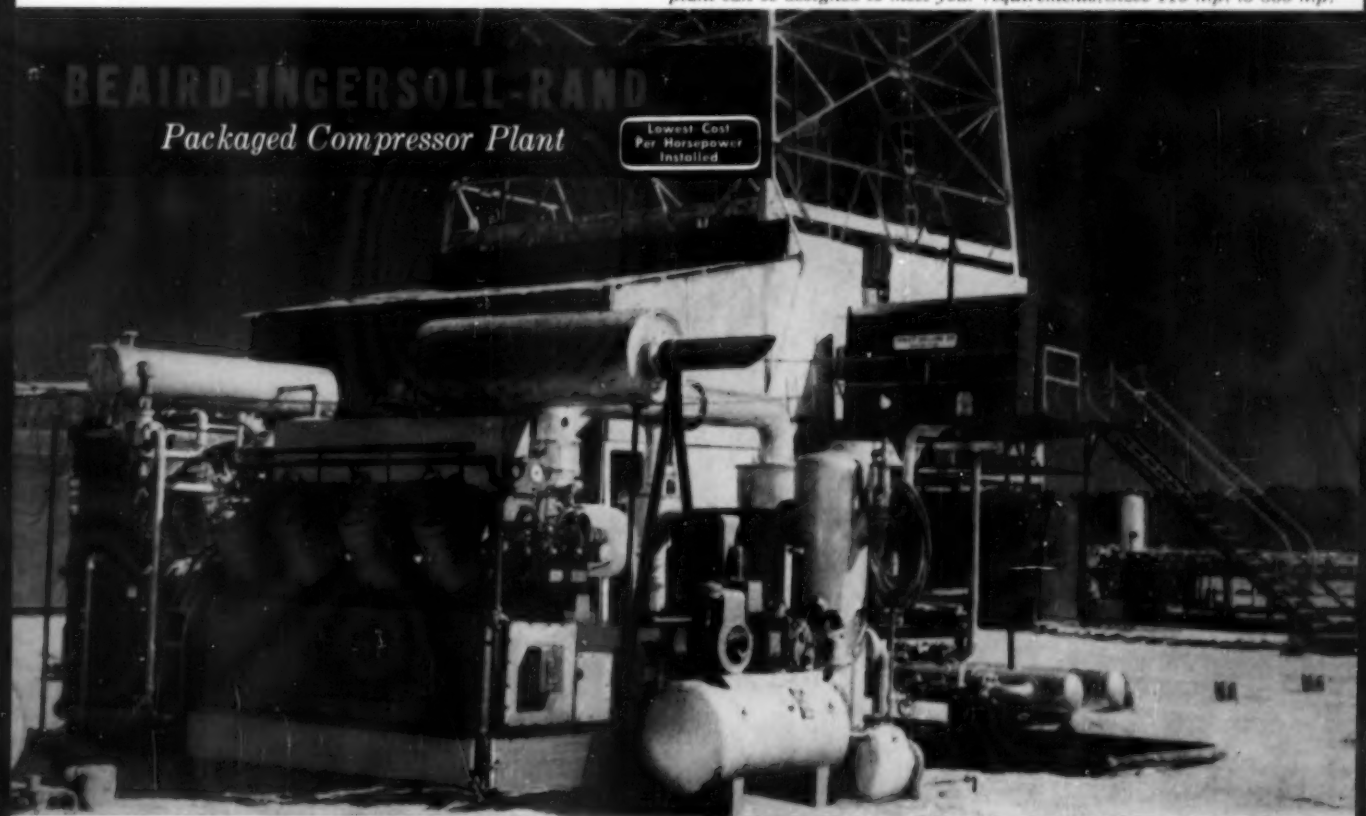
PACKAGED COMPRESSOR *SPEEDS* PENETRATION RATES ON TEST WELLS

OIL INDUSTRY TECHNOLOGISTS, investigating methods of reducing present-day drilling costs, recently started a series of tests using aerated mud. Of major importance to this program was the selection of a compressor. The unit had to deliver, automatically, full rated capacity over a wide range of pressures — to operate virtually unattended, leaving the crew free for regular duties. When moving it was essential that only oil field equipment be used and no special foundation required at the drilling site.

A Beaird-Ingersoll-Rand 4-Cycle Packaged Compressor Plant, 220 horsepower 8 JVG, was purchased by Phillips Petroleum Company for this task. Beaird engineers installed automatic controls that permit it to slow down or pick up speed over a range of 50% to 100% according to discharge conditions. A stop valve on the rig floor is all that is required to shut off air instantly for a connection or a trip. Other automatic controls safely handle this sudden change in operation — slowing the engine and unloading the compressor cylinders.

Mounted on its own heavy steel skid base, the compressor is set in a shallow pit near the rig and ballasted with sand or caliche. It moves as a single over-the-road package between drilling sites. On the new location only connections to fuel and mud lines are required to place it into operation.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your requirements. Sizes 110 h.p. to 660 h.p.



▲ Beaird-Ingersoll-Rand 220 h.p. 8 JVG four-cycle gas engine driven compressor equipped with Young radiator and all necessary equipment and controls on Phillips Petroleum Company's drilling rig.

THE J. B. BEAIRD COMPANY, INC.
Shreveport, Louisiana

BEAIRD

MACHINING • MANUFACTURING • STEEL WAREHOUSE

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

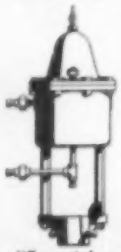
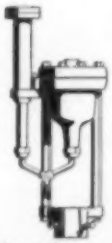
PRESSURE BULK STORAGE

ANHYDROUS AMMONIA EQUIPMENT

LP-GAS SYSTEMS

What's worth metering is worth metering right!

. . . and Foxboro offers the *right* meter for any metering problem. Round and rectangular cases. Meter body types are shown below.

TYPE 22	TYPE 29	TYPE 27	TYPE 28	TYPE 26
				
light weight and low cost, preferred for portable recording, or with 6" indicator, for mounting directly on piping.	for differential ranges as low as 1" H_2O, especially for low pressure gas and air service.	superior general use meter with all Foxboro design features for high sustained accuracy and maintenance-freedom.	longer float travel, greater power, highest accuracy meter ever built.	leakproof measurement at really *high* pressures without compromise in accuracy.

a flow meter type for every need

From its complete line of flow meters, Foxboro can offer the *best* type — in the proper range and static pressure rating — for virtually any metering problem. They are available as indicators, recorders, controllers, and transmitters — with or without integrator. Foxboro also is the maker of the d/p Cell — the compact force-balance type flow transmitter which uses no mercury.

The widest selection of flow instruments is only one of the many factors responsible for Foxboro's acknowledged leadership in flow metering. See how this factor — together with many superior, exclusive design features — give you the most value for your money. Write for Bulletin 460-2 on mercury meters, Bulletin 420-2 on d/p Cells.

Specifications of Foxboro Meter Types Illustrated

TYPE	MATERIAL	MAX. W. P.	RANGES
22	Forged Steel	2000	20"—200"
29	Cast Iron	150	1" —10"
27*	Forged Steel	2000	10"—400"
28	Forged Steel	2000	50"—400"
26	Forged Steel	5000	100"—400"

*Type 27U is a uniform flow scale meter used for steam and other service where demand fluctuates widely. 100" range. Max. W. P. 2000 psi.

THE FOXBORO COMPANY, 741 NEPONSET AVENUE, FOXBORO, MASS., U.S.A.

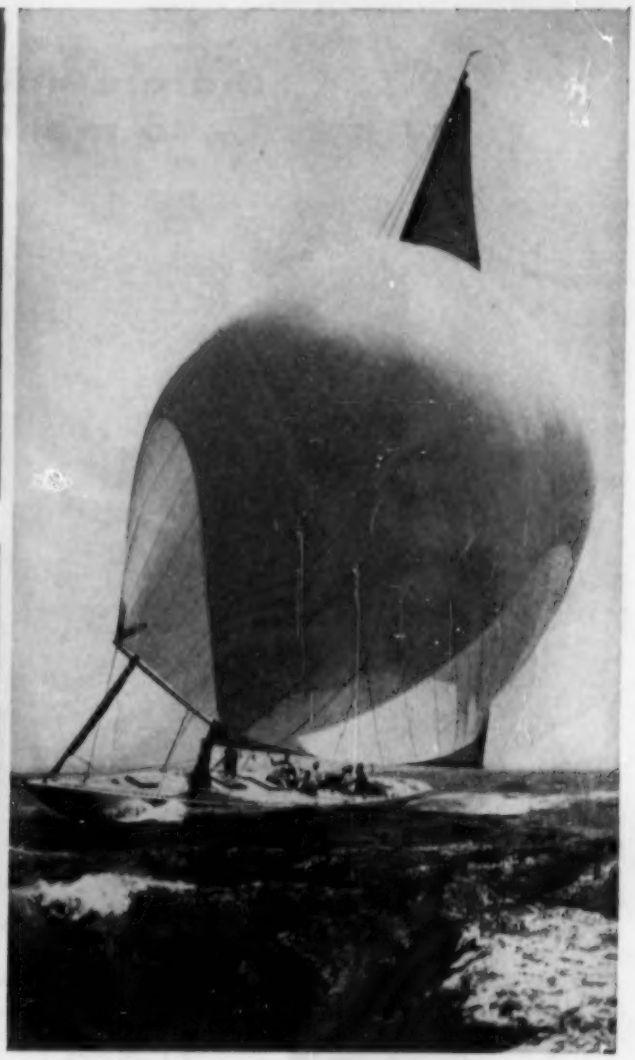
FOXBORO REG. U.S. PAT. OFF. **FLOW METERS**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Enjay helps keep your sales out front

IN SURFACE COATINGS *(Paint and Varnish)*

IN PETROLEUM *(Lubricants and Gasoline Additives)*



IN CHEMICALS *(Synthetic Fabrics)*

Products that lead in sales are the products that deliver dependable quality and performance. And where quality and performance count, rely on Enjay. Enjay supplies the chemical, surface coating and petroleum industries with a complete line of uniform, high quality petroleum chemicals, backed by pioneering research, experience and proved results. Enjay is also ready to assist you in developing new or improved products through chemistry. Call Enjay *next* time for your chemical needs.

Enjay Company, Inc. • 15 West 51st Street, New York 19, N. Y.

PETROLEUM
PARANOX
PARATONE
PARAFLOW
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PARADYNE
PARATAC
PETROHOL
Methyl Ethyl Ketone
Dewaxing Aid
Ethyl Ether
Isopropyl Ether
Reference Fuels

SURFACE COATING
PETROHOL 91
PETROHOL 95
PETROHOL 99
JAYSOL
Secondary Butyl Alcohol
Secondary Butyl Acetate
Isopropyl Acetate
Acetone
Methyl Ethyl Ketone
Dicyclopentadiene
Ethyl Ether
Isopropyl Ether
Naphthenic Acids
Iso-Octyl Alcohol
Decyl Alcohol
Denatured Ethyl Alcohol

CHEMICAL
PETROHOL 91
PETROHOL 95
PETROHOL 99
JAYSOL
Iso-Octyl Alcohol
Decyl Alcohol
Denatured Ethyl Alcohol
Tridecyl Alcohol
Dicyclopentadiene
Isop[illegible]ne
Bu[illegible]tone
Ethyl Ether
Isopropyl Ether
Tetrapropylene
Tripropylene
Aromatic Tars
Benzene
Acetone
Methyl Ethyl Ketone

ENJAY

35 successful years of leadership in serving industry

For more data on advertised products, use Readers' Service Cards, last page.

Evenly matched or not...

there's enough difference to make all the difference

Before the bout, two fighters may look equally good to the fans. After a round or two, the differences begin to show up.

It's the same with heat exchanger tubes. They all start out looking pretty much alike, but under the test of day-in, day-out operation, Scovill Phosphorized Admiralty Heat Exchanger Tubes have consistently shown superior performance.

Hot-extrusion from Scovill Continuous-Cast billets means uniformity in the metal, uniformity of chemical composition and grain structure, uniformly high phosphorus content. It means sounder metal—smooth, dense, free from pits or porosity. These—plus Scovill's unrivaled Technical Application Services—are, indeed, differences that make *all* the difference in economical, uninterrupted service under tough operating conditions. Let us tell you more about them.

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

SCOVILL **HEAT EXCHANGER TUBE**

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

SOCSS

She tests her purchases **Do you?**

If you are the average cooling tower owner, you do not test your purchase. In fact, Mr. Average Owner knows less about the actual performance of his cooling tower than his wife does about the interior of the melon to which she has applied the "squeeze and sniff" test. True, cooling towers are purchased for a specified performance; but the difference between "specified" and "actual" is sometimes astounding and only a test will tell.

"Test Your Tower," a new Marley technical publication, outlines a simplified straight-line method by which you can test your industrial cooling tower and arrive at positive results. By applying this test you *know* whether or not your "guaranteed" tower does the job it was specified for.

You can test your tower under any normal operating condition, and the Marley method of analysis will give you an accurate, conclusive comparison with guaranteed performance. Fill in the coupon, get your copy of "Test Your Tower" . . . then test it. Your Marley engineering service representative in major cities can also supply this brochure, just call him.

MAIL COUPON TODAY

MARLEY

Founder-member of the Cooling Tower Institute

The Marley Company

Kansas City, Missouri

Technical Services Dept.
The Marley Company
228 W. Gregory Blvd., Kansas City, Mo.

Please send me a copy of your new brochure, "Test Your Tower."

Name.....

Firm.....

Address.....

City..... State.....

For more data on advertised products, use Readers' Service Cards, last page.

PROVED for

●Certainly, centrifugal compressors are practical for high pressure applications. Clark has been building them for years.

Installations on pipelines, in chemical processing plants, wind tunnels, catalytic reforming and field repressuring have *proved* Clark high pressure "centrifugals" to be entirely dependable and practical. Clark-proved design features make pressures up to 2500 psi completely feasible!

For moderately high pressures, Clark builds horizontally split cases for greatest accessibility. Available in either cast semi-steel or cast steel, with either up or down connections to fit your piping requirements, these cases are ideally suited to high pressures because of their compact, rugged construction. Cast-in, integral bearings assure permanent, built-in alignment, without the use of a costly fabricated base.

For pressures beyond the range of horizontally split cases, Clark builds vertically split, barrel-type units of either cast or forged steel construction.

In either Clark design, sealing—*of prime importance to any high pressure centrifugal*

Clark Horizontally Split Case
Pressures to 900 psi

Clark sets the pace in compressor progress

CLARK

high pressure applications

compressor — presents no problem. Dependable, proved, oil seals *originated by Clark* hold the gas in the case where it belongs. Many parts, including the seals, are interchangeable between the two compressor designs.

Where extremely high ratios are encountered, the Clark design lends itself readily to drive-thru. Two or more cases can be driven by a single turbine or motor for maximum installation and operating economy.

Clark experience in handling practically all gases from hydrogen to butane, in a vast number of applications, is a real time and money-saver by eliminating the need for performance-testing. Only a mechanical test is required. Clark *knows* the performance of its machines.

For complete information, consult your nearest Clark representatives and request Bulletin 116.

CLARK BROS. CO. • OLEAN, N. Y.

ONE OF THE DRESSER INDUSTRIES

Sales Offices in Principal Cities Throughout the World

Clark Vertically Split Case
Pressures to 2500 psi

MULTI-STAGE

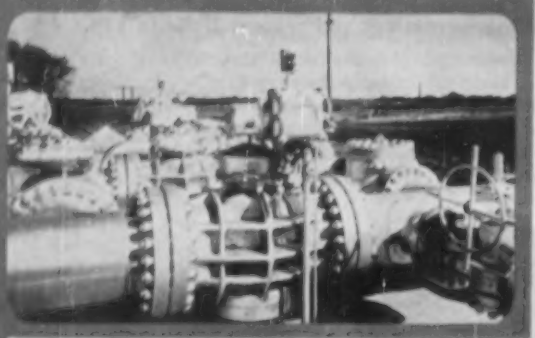
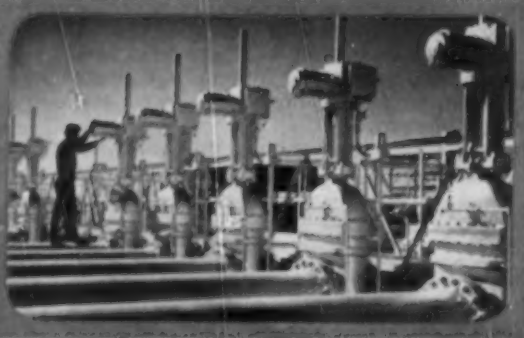
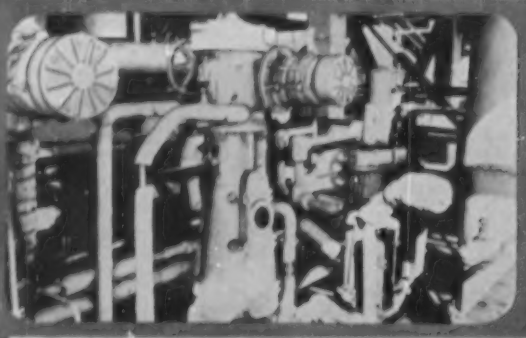
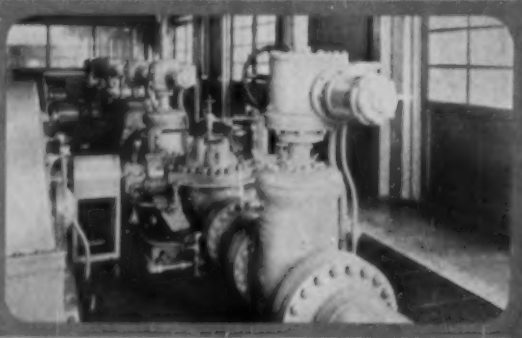
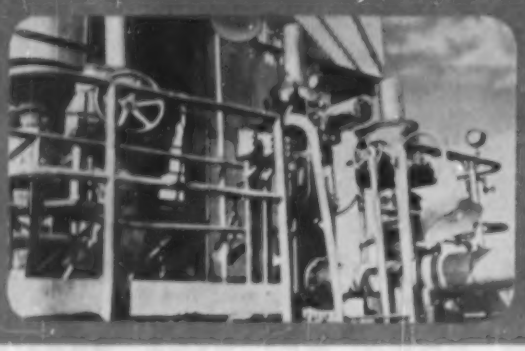
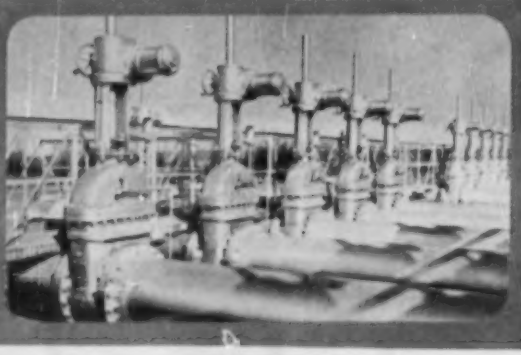
centrifugal compressors

For more data on advertised products, use Readers' Service Cards, last page.

FACTS SPEAK LOUDER THAN WORDS

...more *Limitorque*

MOTOR OPERATED VALVE CONTROLS are used in PIPE LINES and REFINERIES throughout the world than all other makes

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Established 1892

You Can't Read This Ad Without Visualizing Tremendous Savings in Your Plant

If the handling of bulk materials is required in your plant, be they raw, finished, moist, liquid or rubbish materials, read these simple facts about the Dempster-Dumpster System. Then, visualize its application and tremendous savings possibilities in your own operation.

VISUALIZE HAVING ONLY ONE TRUCK with scores of bodies. One truck-mounted Dempster-Dumpster with only one man, the driver, serving many detachable Dempster-Dumpster Containers. These containers range from 2 to 21 cu. yds. capacity for use with recommended type Dempster-Dumpsters, and each container built to suit the materials to be handled—be they solids, liquids, dust, bulky, light or heavy. You place a container at convenient materials accumulation points, in or out of plant. As each is loaded, it is picked up, hauled and dumped, or the load is set down intact, and the entire operation is handled by hydraulic controls in cab by only one man, the driver.

The photographs above were made in the plant of one of the nation's leading brands of soaps and dentifrices. This installation comprises a single Dempster-Dumpster and 49 containers. Photos illustrate the simple one man pick up, hauling and dumping operation of a drop bottom container.

THE NATION'S LEADING FIRMS USE THIS SYSTEM BECAUSE OF ITS AMAZING EFFICIENCY AND TREMENDOUS SAVINGS.

YOU ELIMINATE trucks standing idle . . . eliminate re-handling of materials . . . eliminate loading crews. You increase efficiency, sanitation and good plant-keeping with this amazing Dempster-Dumpster System—the lowest cost method of bulk materials handling ever devised. Write us now for complete information. Manufactured and sold exclusively by Dempster Brothers, Inc.

One Truck-Mounted Dempster-Dumpster Handles Scores of Containers... All Designs...All Sizes

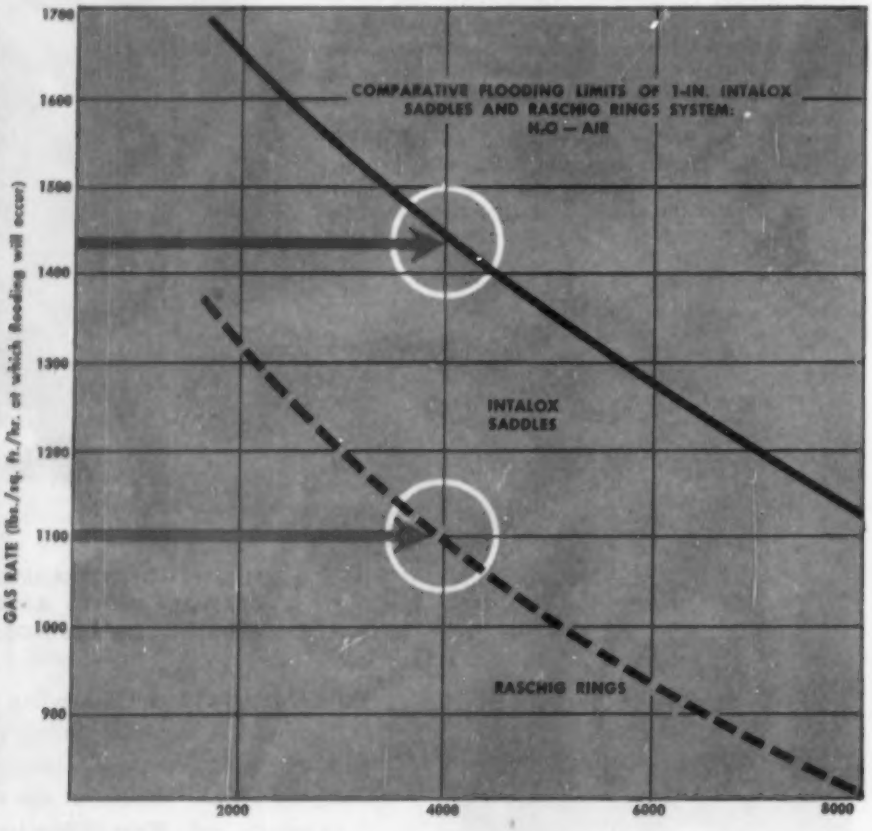
DEMPSTER BROTHERS, 515 Dempster Bldg., Knoxville 17, Tennessee

HOW INTALOX SADDLES CAN ADD 30% OR MORE SCRUBBING CAPACITY TO YOUR TOWER

THE higher flooding limits of Intalox saddles offer another convincing factor in any study of relative efficiencies.

For example — if your present tower is packed with Raschig rings, and the tower is now operating to the full limit of its capacity, you can increase its capacity 30% or more by replacing the Raschig rings with Intalox saddles.

Take a look at the chart below showing the comparative flooding limits of 1-in. Raschig rings and 1-in. Intalox saddles at various liquid and gas rates. It was prepared from data based on repeated observations by independent authorities. Suppose a tower packed with Raschig rings is operated at a fixed liquid rate of, say 4000 lbs./sq. ft./hr. Flooding will occur at a gas rate of 1100 lbs./sq. ft./hr. But if the Raschig rings are replaced with Intalox saddles, the gas rate can be increased to almost 1450 lbs./ sq. ft./hr.



Higher flooding limits are only one of the many advantages you obtain with Intalox saddles. The unique, patented "shape" results in a packed bed of greater randomness. There is more surface area per cubic foot, and even more important, virtually all surface area is effective area. There is more free space, and the free space is more uniform.

It will pay you well to learn more about Intalox Saddle packing and how it can help you reduce tower construction and operating costs. Write for Bulletin IS-29.

15X

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Process Equipment Division **AKRON 9, OHIO**

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DAVISON M-S® Catalyst

The Petroleum Industry's MOST WIDELY USED CATALYST!

- Narrow range of particle size distribution
- Low impurities
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- Excellent attrition resistance

These are some of the reasons why Davison's Catalysts are the most widely used synthetic cracking catalysts in the petroleum industry. Throughout the world, Davison's catalysts crack more gas oil than any other catalyst.

Write today for a folder giving all the facts on Davison's M-S Catalysts . . . particle size distribution, chemical, physical and catalytic properties, etc.

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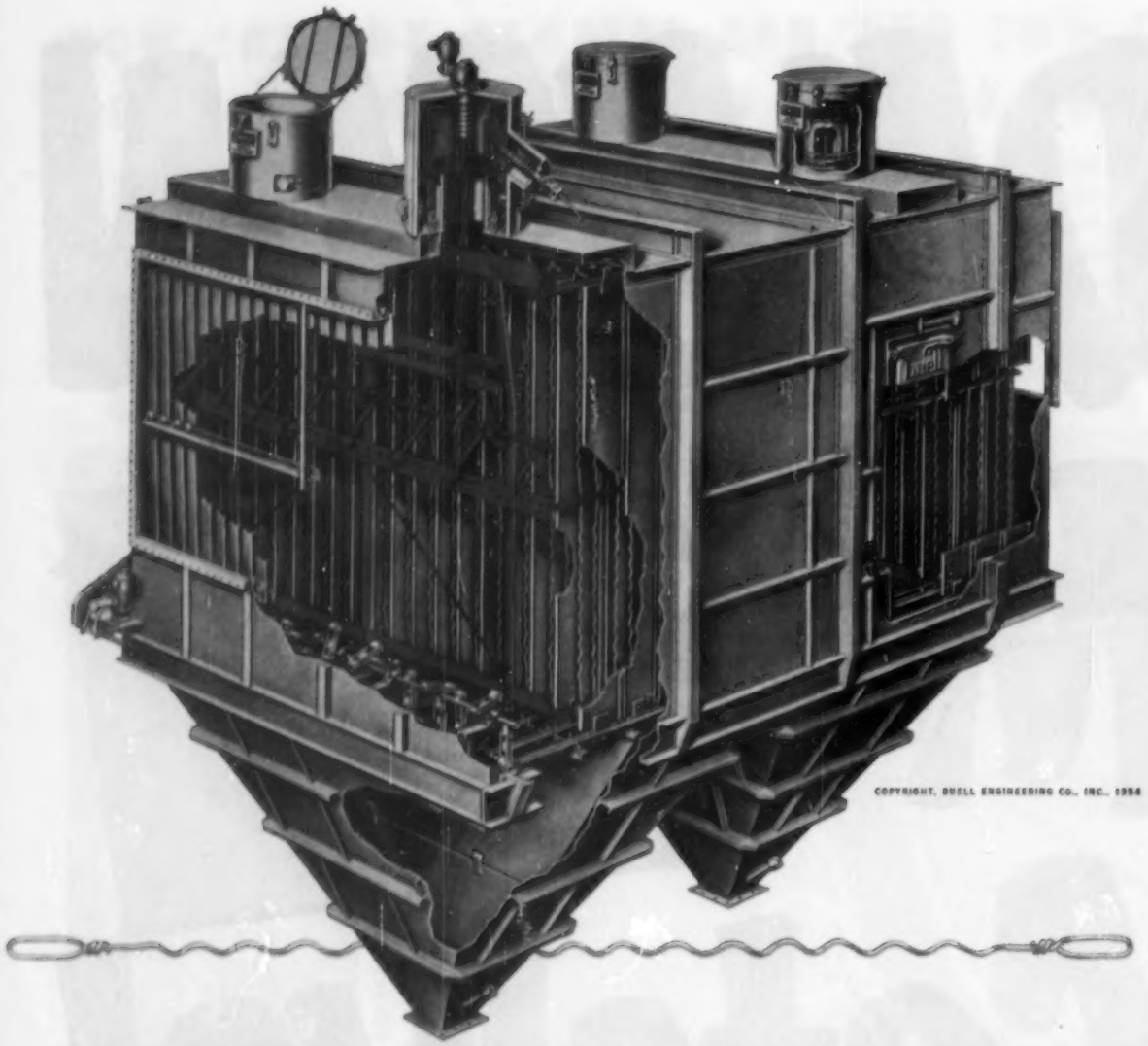


World's Most Effective Dust Collector

Already you have heard about the amazingly high efficiency and low maintenance of Buell "SF" Electric Precipitators. Now... we'd like to tell you about the Buell *exclusives* that make these money-saving advantages possible!

➤ **Spiralectrodes** permit higher emission than any other electrode... result in unequalled efficiency in industrial dust collection.

➤ **Continuous Cycle Rapping** eliminates "puffing," keeps electrodes constantly clean, prevents re-entrained dust... maintains peak efficiency.

➤ **Positive Flow Control** by specially designed baffles prevents channeling, scouring and harmful eddies.

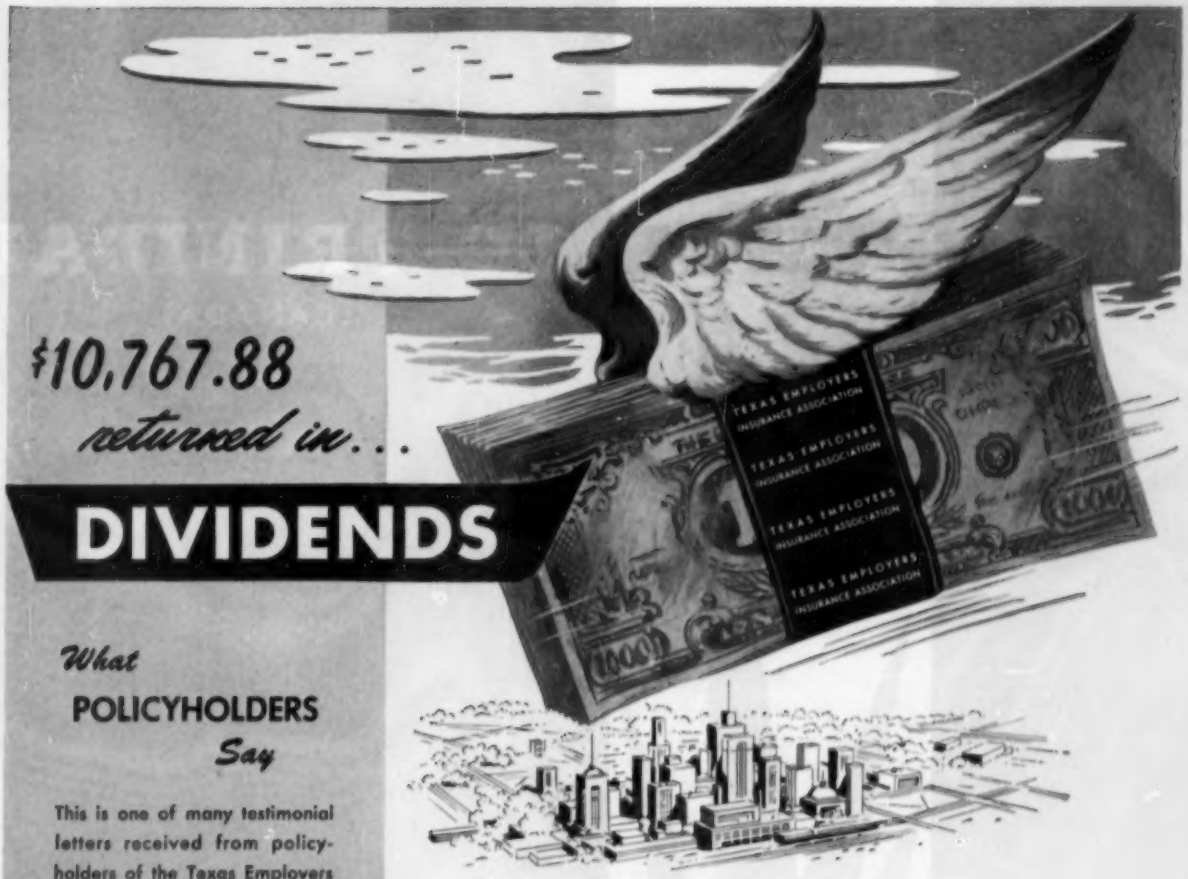
➤ **Sectionalized Design** permits wider safety margins and more reliable service... keeps maintenance extra simple... eliminates need for complete shutdown.

Write today for a free Brochure which describes *all three* of Buell's proven systems—The Collection and Recovery of Industrial Dust. Dept. 21-A, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell® MECHANICAL ELECTRICAL

20 Years of Engineered Efficiency in

DUST COLLECTION SYSTEMS



What POLICYHOLDERS *Say*

This is one of many testimonial letters received from policyholders of the Texas Employers Insurance Association. These letters tell what policyholders think of the Service and Savings received from the Association.

Ask the Texas Employers representative nearest you to show you more of these letters, as proof of what Texas' largest writer of Workmen's Compensation Insurance can do for you.

WE QUOTE FROM A POLICYHOLDER'S LETTER:

"I certainly wish to thank you for your visit to our office last week when you again handed us a very nice dividend check in the amount of $10,767.88.

"Our birthday with your Company is about the same time as yours, and our services have been gradually improving, we think, in all departments. I am particularly impressed with the improvement in the Departments of Claims and Safety, at the present time.

"I have shown your reports to our Safety Representative, and I think he was somewhat proud of our safety record, as he should be."

Largest Writer of WORKMEN'S COMPENSATION INSURANCE *in Texas*

HOMER R. MITCHELL, *Chairman of the Board* A. F. ALLEN, *President*

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TEXAS EMPLOYERS INSURANCE ASSOCIATION
HOME OFFICE - DALLAS, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

MORE POWER TO TRINIDAD.

(CANADA)

. . and to Trinidad's customers with Platforming

HERE'S ANOTHER EXAMPLE of the remarkable results now being obtained with the UOP Platforming process. It is also an example of progressive thinking . . . and progressive acting . . . on the part of Trinidad Leaseholds (Canada) Limited.

By installing this UOP Platformer, Trinidad has greatly improved its position as a producer of high quality motor fuels. Former refining methods required the use of almost the maximum amount of tetraethyl lead in order to meet octane requirements of Trinidad's marketing area. With the Platformer, Canadian crudes are being processed . . . the octane numbers have been substantially raised . . . and a sharp reduction in the amount of tetraethyl lead used has been accomplished.

The finished product . . . well above average octane for the southern Ontario marketing area . . . enables Trinidad to supply its 500 retail outlets with an exceptionally high quality motor fuel on a more profitable basis than was possible before.

Trinidad's Platformer has a design capacity of 1,500 B/SD. However, provision has been made to raise the capacity to 2,300 B/SD in line with a planned modernization program which will result in Trinidad doubling the daily throughput of its refinery.

Platforming . . . the catalytic reforming process which pioneered the use of platinum catalyst . . . offers many important advantages. Why not talk over with us the application of Platforming to your operation?

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Universal Service
Protects Your Investment

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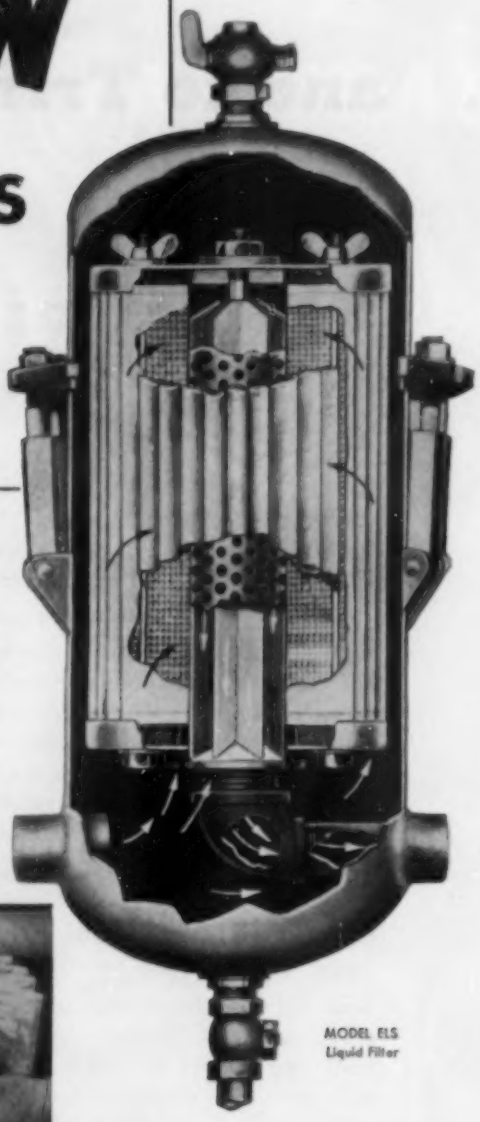
LIQUID FILTERS

Solve Your Filtration Problems!



MODEL ELS
Liquid Filter

Bring your liquid filtration problems to Dollinger engineers. Their specialized experience is available in recommending the most efficient and economical equipment for filtering liquids in a wide range of viscosities, temperatures, acidities, alkalinities, pressures and capacities.

Staynew exclusive design, permits use of *any medium in sheet form that can be crimped.* Metal, plastic, fabric, ceramic and metallic mesh media can be used for super-fine filtration.

Write us today outlining your specific liquid filtration problem. From our 30 years experience in liquid filtration, we have built up a vast file of helpful information. Any part of this information is yours for the asking—no obligation.

Staynew Radial Fin Construction provides the largest possible filtering area for available space. Slip-On Insert—exclusive in Staynew Filters—permits simple, inexpensive cleaning or replacement of media.

Representatives in Principal Cities

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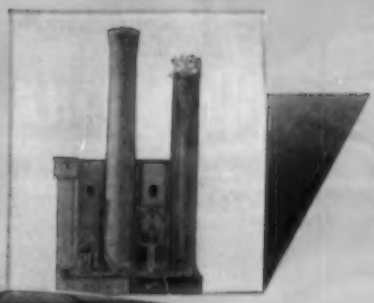
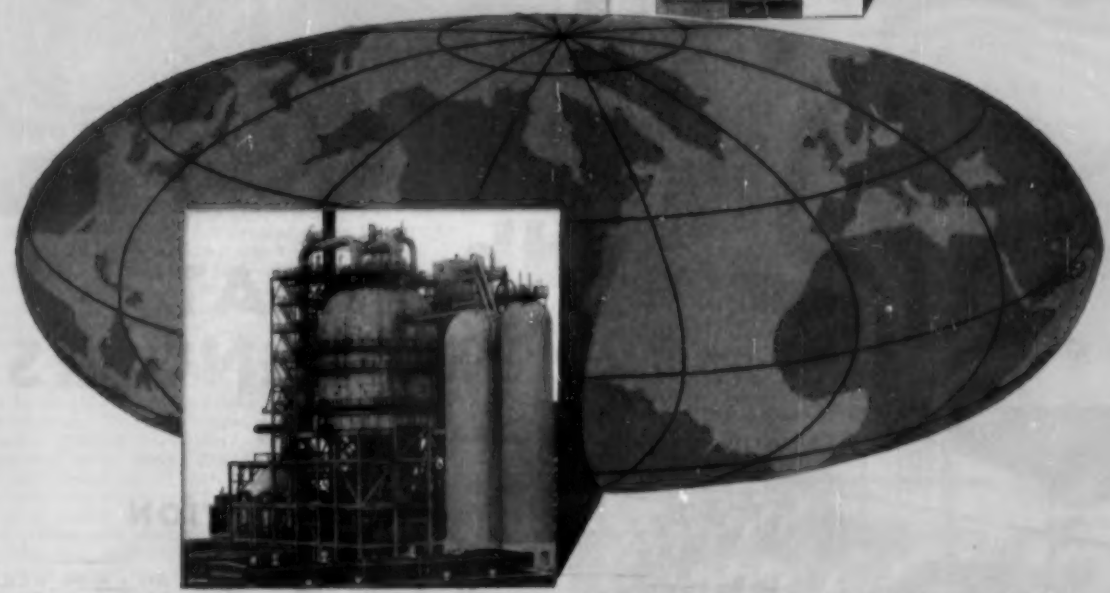
ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

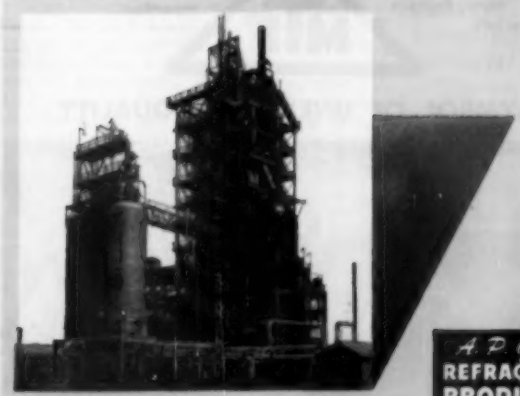
ALL OVER THE WORLD

A. P. GREEN

Serves the Refinery Industry with a Complete Line of High Quality Refractory Products







Throughout the world, the refinery industry relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, etc.

A world-wide network of A. P. Green distributors is always ready to help you select the right refractories to do the best possible job . . . at the lowest cost. Regardless of location, A. P. Green refractories reach you quickly, safely, exactly as ordered.

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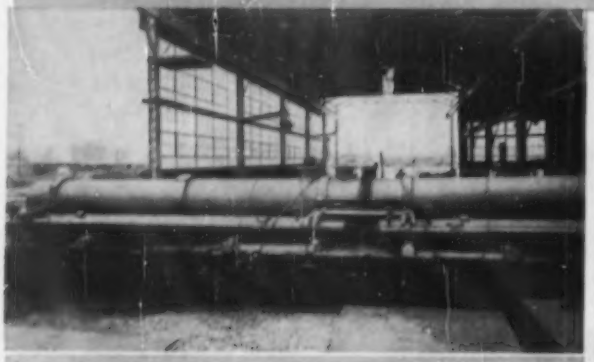
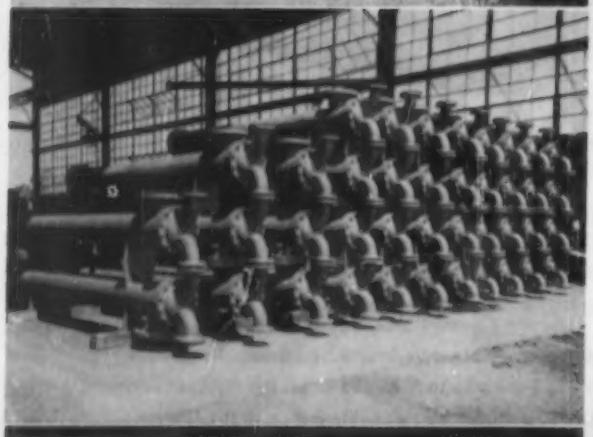
SPECIALISTS IN HEAT EXCHANGERS FOR THE PETRO-CHEMICAL INDUSTRY





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Qualified for Construction in Ferrous and Non-Ferrous Materials

API - ASME and ASME Code Construction.

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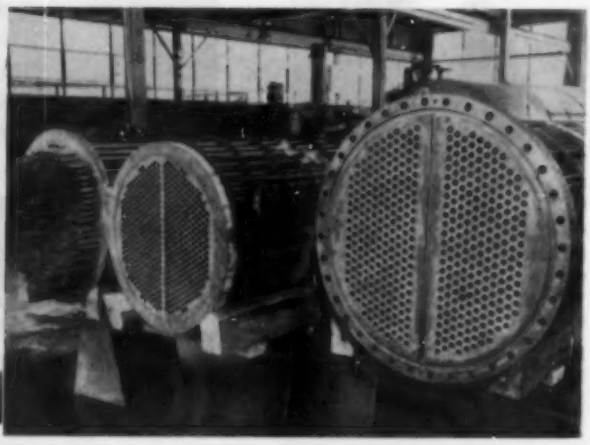


The Mail Box . . .

Author Reminisces as November Issue Is Read

To the Editor:

The November issue of PETROLEUM REFINER reminded me of a number of past experiences, the most recent one being the pleasant visit with you and your associates a couple of months ago in Houston.

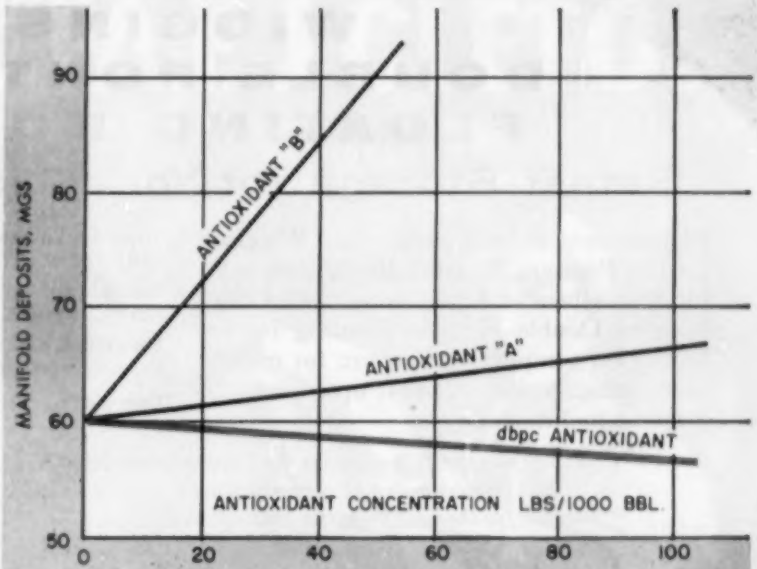
Regarding the recent comment in "B. S. & W." about the smog in Los Angeles, when I visited there a couple of years ago, my eyes were constantly irritated but I never thought of attributing it to the exhaust from automobiles. If that were responsible, then how about carbon monoxide? From experience, I know that a little goes a long way. There should be enough to give the whole city a beautiful headache, literally as well as figuratively. Without definite proof to the contrary, I would be inclined to string along with the governor.

The article on the "New Chlormethane Plant" took me as far back as 1919 to 1921, which indicates that, although the plant may be new, the process isn't. This was the second chemical process in my experience—the first one being sodium ex salt—and it was very educational, as well as a challenge, for an engineer. Surprising as it may seem, one of our problems was the removal of 25 percent ethane from the natural gas which we burned as fuel. I don't think there is any gas of that composition in West Virginia today. Other problems were the disposal of hydrochloric acid and methylene chloride. There was no market for either but several years ago I saw an operation in which methyl chloride was being chlorinated to produce methylene chloride. The last straw, which resulted in shutting down the plant, was the depression in the early '20's. The process was invented about 20 years too soon and I have frequently thought about how much easier it would be to build and operate such a plant with the better materials and facilities now available. However, I guess the same might be said of almost any process more than ten years old.

Next, "Starting Up a New Ammonia Plant." In 1925 I was assigned the job of helping to evaluate the use of by-product hydrogen from a sodium cyanide operation to manufacture synthetic ammonia. As a result, a plant was designed and put into operation without bringing in outside help and with not a single member of the organization ever having been in an ammonia plant. If the Phillips process engineering group think they had problems, they can perhaps imagine what the situation was almost 30 years ago. Having never worked with pressures over 200 psi, 5000 psi gave me much more cause for concern than 50,000 psi would today.

Finally, the article, "New Alloys for Multi-Layer Vessels," by G. E. Fratcher of A. O. Smith Corporation. In 1929 I contracted with this company to build several thick-walled vessels of a chrome vanadium steel for a 5000 psi methanol plant. These were, I believe, the first vessels of any size to be fabricated by welding for a pressure of this magnitude. I recently received some literature from A. O. Smith and they still show what happened to one of the smaller vessels which was tested to destruction. It was 26 inches id by 15½

Engine Tests prove . . .



PETROLEUM PROCESSING, JULY 1954, P. 1044-45.

dbpc Antioxidant contributes NO manifold deposits

Three antioxidants were tested in a blend containing 60% catalytic cracked and 40% thermal cracked gasolines. The antioxidants tested were **dbpc**® inhibitor* and antioxidants "A" and "B" — other well-known commercial gasoline gum inhibitors.

The manifold test unit consisted of a specially-designed manifold attached to a single-cylinder, air-cooled engine, with provisions for control of fuel rate and temperature. The air-fuel mixture from the carburetor entered the manifold which was heated by two 500-watt, pancake electric heaters attached to the manifold exterior. Manifold temperature averaged 255° F.

dbpc (indicated in red) did not contribute to manifold deposits. Actually, it tended to *reduce* deposits. Antioxidants "A" and "B" however, *increased* manifold deposits.

dbpc is safe and easy to handle. It is economical, highly soluble in gasoline and is inert to extraction by caustic and water and the commonly used pipe corrosion inhibitor.

dbpc is also supplied in easy to handle liquid form as Impruvol 33® antioxidant.

For full information write:

*2, 6 di-tert-butyl-para-cresol

KOPPERS COMPANY, INC.
Chemical Division, Dept. PR-15, Pittsburgh 19, Pennsylvania

KOPPERS ® **Koppers Chemicals**

SALES OFFICES: NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
CHICAGO · DETROIT · LOS ANGELES

For more data on advertised products, use Readers' Service Cards, last page.

WIGGINS DOUBLE PONTOON FLOATING ROOFS

Safest Storage for Your "Liquid Assets"

Performance records prove that Wiggins Double Pontoon Floating Roofs soon pay for themselves in liquid conserved. Only Wiggins Double Pontoon Floating Roofs have every important feature for maximum conservation . . . safest operation . . . low-cost maintenance.

Triple Seal increases conservation savings and adds extra safety.

Multiple gas-tight pontoon compartments increase safety, strength and buoyancy.

Simplified design gives strength with minimum trussing, making inspection and maintenance easy.

Complete, clean drainage reduces corrosion problems.

Get the full story on the General American-Wiggins system of petroleum liquid conservation by writing us on your letterhead for the new Wiggins Manual WP-14.

Wiggins Double Pontoon Floating Roofs, Dry Seal Gasholders, Lifter Roofs, Cone Roofs

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 SOUTH LA SALLE STREET · CHICAGO 90, ILLINOIS

feet long with a wall thickness of 3-3/32 inches and had a volume of 61.5 cubic feet. Failure took place at 12,600 psi whereas the calculated bursting pressure was 18,200 psi. The way the vessel shattered was a good lesson to all of us regarding the energy that can be built up in water at high pressure. When making a hydrostatic test, its a good idea to keep the volume of liquid to a minimum and then keep a healthy distance away. Needless to say, A. O. Smith didn't make a profit on this job but it did result in their development of the layer-type construction. I was interested to note in the article that they referred to the "delta" joint which happens to have been originated by me.

There is always something worthwhile in each issue of PETROLEUM REFINER but the foregoing indicates why the recent one was of particular interest to me. Some time in the near future I hope to prepare an article on one of several subjects, about which I have been thinking, and I will offer it to you for consideration.

Walter Coopey,
Engineering Consultant
Charleston, W. Va.

Author Is Grateful

To The Editor:

I was happy to receive your letter informing me that you had accepted for publication my article "How to Desulfurize Diesel Fuel," and I want to express my gratitude for your interest and kind help. The manner in which you guided my work toward publication was a fine demonstration of your editorial policy.

Tibor S. Laszlo,
Department of Chemistry
Fordham University, New York

Carbon Black Interest

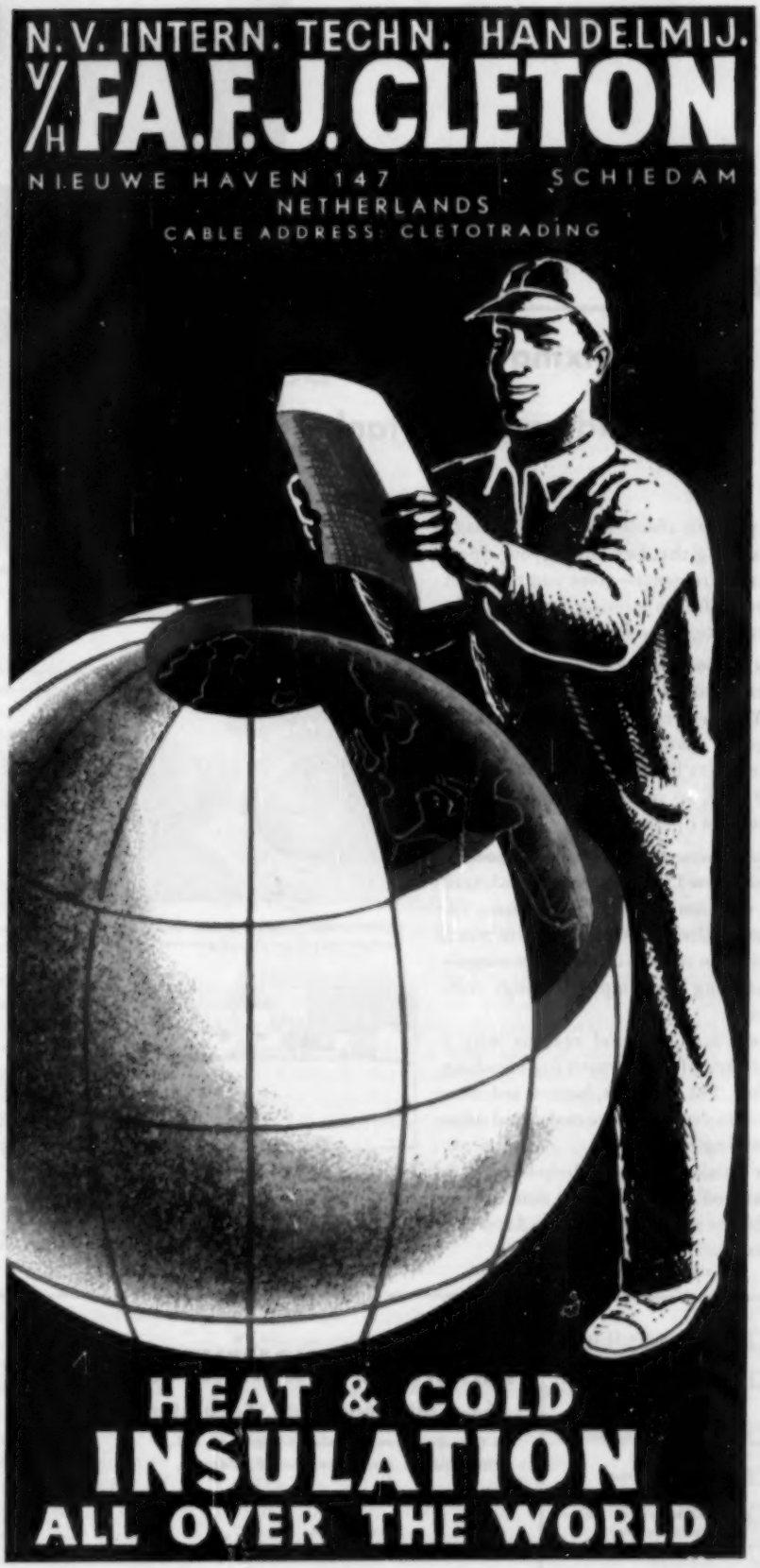
To the Editor:

You have published in the Petrochemical Process Handbook page 174 the flow sheet for carbon black manufacturing.

I am interested in this manufacturing and would be grateful to you for indicating to me the address of the Continental Carbon Black Company or any company in this line.

Edmund Riba
Lisbon
Rua Silva Carvalho 20
Portugal

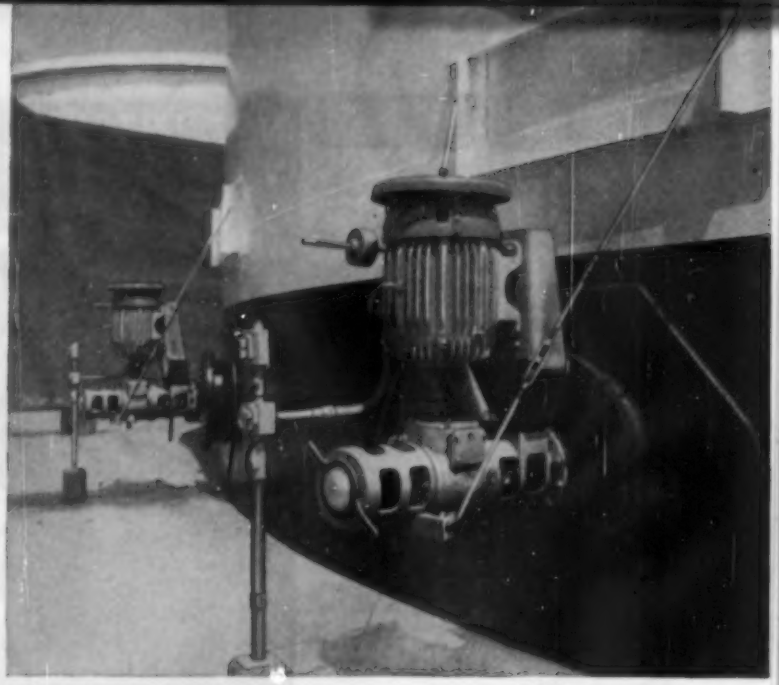
The Editors invite PETROLEUM REFINER readers to use this "Letters Column" to discuss pertinent topics of timely interest to the industry.



For more data on advertised products, use Readers' Service Cards, last page.

2 tested ways to CUT COST

of mixing and blending in big tanks



YOU CAN REPACK the stuffing box or replace the rotary mechanical shaft seal on a LIGHTNIN Side Entering Mixer, under a full head of 5 million gallons—without losing a pint of product.

Now you can *choose* the kind of mixer shaft sealing that best meets your operating requirements—gives you the most in trouble-free operating hours . . . in maintenance dollars saved.

1. You get easier repacking than ever with the standard LIGHTNIN packed stuffing box. You need never take the tank out of service to change packing. The mixer shaft retracts like a valve, sealing liquid in the tank, so you can repack in a jiffy and resume operation.

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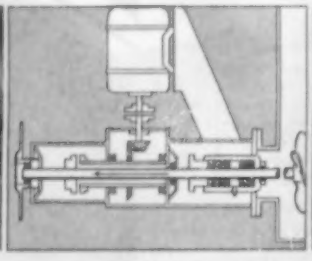
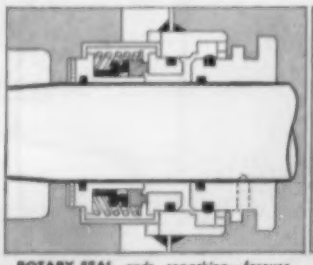
STUFFING BOX repacking is fast, simple. Turning this easy-to-get-at bearing member...

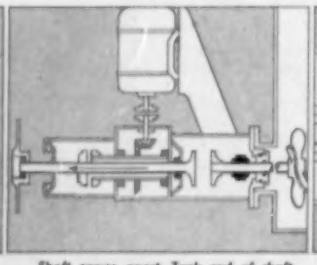


...retracts the mixer shaft outward, like the stem of a valve. Inside the tank...

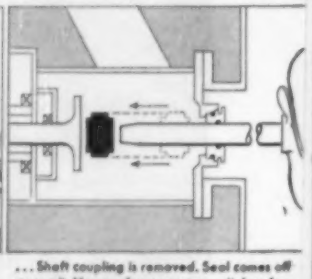
...a Teflon "O" Ring squeezes against the shaft and flange hub, keeping product safely in the tank while you change packing.



ROTARY SEAL ends repacking—forever. Seal runs without adjustment for its lifetime. Easy to replace, too...



...Shaft comes apart. Tank end of shaft locks in place and seals liquid safely in the tank...



...Shaft coupling is removed. Seal comes off as a unit. New seal goes on as a unit. In a few minutes, you're back in operation.

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The LOOK BOX for January . . .

Oil Industry Is House Divided

A SAD and paradoxical chapter in legislation affecting the oil industry will go into the records of the new Congress that convened this month.

Oil men will tell the Congress to stop its senseless meddling in industry affairs.

Some of the same oil men will then plead with Congress for greater regulation of industry affairs.

This irony stems from the two greatest problems confronting our industry as 1955 begins:

1. The necessity for legislating into limbo the Supreme Court's ruling in the Phillips Petroleum Company case, which holds that the Federal Power Commission has jurisdiction over natural gas producers who sell their product to regulated interstate pipe line companies.

2. The necessity for determining an imports ratio which will at once protect the foreign investment of U. S. companies and maintain the health of the domestic industry.

The first problem has an excellent chance of being solved in this Congress through the efforts of a united industry and with the sympathetic aid of congressmen, who, on their record, will support a bill to amend the Natural Gas Act. Notable among these are House Speaker Sam Rayburn of Texas and Senate Majority Leader Lyndon Johnson, also of Texas. There is also every reason to believe that President Eisenhower will not follow the example of President Truman, who in 1950 vetoed the Kerr Bill after this clarification of the Natural Gas Act was fought through the Congress.

Among those with the greatest stake in the overthrow of the Phillips mandate, and who thus can be expected to be among the fiercest proponents of corrective legislation, are the independent producers. It is this group which will simultaneously lead a fight for legislation curbing the activities of another segment in the oil family, the importers.

In preparation for this struggle the Texas independents last month drafted a program designed to muster all the nation's independents—and their congressmen—behind legislation to curb imports.

The chances of such legislation are doubtful in view of President Eisenhower's announced intention of asking Congress to give high priority to a liberalized foreign trade program. Most Democrats and middle-of-the-road Republicans will support the President's request for a three-year extension under which he would be allowed to cut tariffs as much as 5 percent a year for a total of 15 percent. Strong opposition is to be expected from conservative Republicans as well as oil and coal state legislators who are fighting imports.

Congressional consideration will also be given to many other issues of concern to oil:

- Twenty-seven and one-half percent depletion allowance—Another effort will be made to reduce the allowance, which is the very life blood of the producing industry. It will fail.
- Taft-Hartley labor-management act—It will be kept virtually intact. A strong coalition of conservative Southern Democrats will see to that. President Eisenhower will suggest changes, among them a ban against employers hiring non-strikers during a strike, and to require employers, as well as union officials, to sign non-Communist oaths. These amendments may pass. On the other hand, a union-backed drive to scuttle right-to-work laws in 17 states will fail.
- Minimum wage—The Democrats are expected to support an Administration proposal to increase the national minimum wage—affecting 24 million workers—from the present 75 cents-an-hour scale to 80-90 cents. Outlook for passage is good, despite some Southern opposition.
- Taxes—Corporation and excise cuts due April 1 will be posponed. The President has warned that the $3 billion revenue involved is needed to reduce a threatened $5 to $6 billion deficit in fiscal 1955-56 in the face of a $63 billion budget.
- Anti-trust and fair price laws—Democrats are determined to strengthen the anti-monopoly statutes and kill the Supreme Court-endorsed state fair price laws. Outcome conjectural.
- Atomic energy—The Democrats plan a drive to head off the President's so-called "give-away" program under which the Administration is trying to induce private enterprise to take a greater part in exploiting nuclear energy for industrial and other peace-time purposes. Outlook uncertain.
- Foreign aid and national defense—The Democrats have already promised the President that there will be little controversy in these fields.

Other issues on which it is too early to prophesy

Du Pont's new polymeric additives help prevent engine sludge under low-duty driving conditions

Which of these two new lube oil additives will do most to help sell your motor oil?

If you are looking for an outstanding sales theme to help expand your motor oil market, here are two entirely *new type* Du Pont lube oil additives that offer just such an opportunity.

Both are *polymeric* additives that provide an economical and effective means of preventing engine oil sludge . . . particularly under low-temperature, low-power, stop-and-go driving conditions. Both do double duty as detergents and V. I. improvers.

As such, they can add important sales appeal to your products in the mass passenger car field as well as in taxi and other urban fleet markets.

With either of them, in multigrade oil formulations, you supply not only superior low-duty detergency, but also *provide a substantial part* of the viscosity index improvement required.

Usually such formulations produce better performing oils at lower cost than can be obtained through other additives or methods.

DU PONT LUBE OIL ADDITIVE 564 is a new type polymeric additive which, because of its relatively low molecular weight, provides your oil with excellent shear stability in engine operation.

DU PONT LUBE OIL ADDITIVE 565 has a higher molecular weight than Lube Oil Additive 564 for greater viscosity index improvement.

Form No Sludge

These ashless polymeric lube oil additives permit more efficient operation of the engine oil system. Oil screens, rings, pistons, filters and other engine parts are kept clean and free from sludge. The resulting free flow of oil throughout the entire engine system keeps it in better operating condition for longer periods of time.

Commercial quantities of both additives are now available. For testing their effectiveness in your own motor oils, any of our regional offices listed below will be glad to supply you with samples.

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action are health re-insurance, which died in the last Congress; safeguards for small business, which will have a loud voice during the session; and expansion of social security to include millions of disabled workers.

Lowered Stocks Brighten Outlook

VAST IMPROVEMENT in the petroleum stocks situation during the past month has made the industry's economic outlook much better than it has been in a long time. Ahead is an opportunity to avoid excessive motor fuel stocks this year, and escape the uncertain conditions that have plagued the industry the past two years.

U. S. refiners have performed a masterful job of regulating product yields to needs during the last four months. Consequently, heavy withdrawals have reduced excessive motor fuel inventories.

As late as June gasoline stocks had been 28 million barrels higher than a year ago at the same time.

Since the end of March, stocks reductions have amounted to about 30 million barrels this year in contrast with the subnormal total of only 12 million in the same period of 1953.

If product of motor fuel can be held down in favor of heating oils output during the first three months of this year, the outlook should continue bright.

About Gas Regulation

AMONG THE questions in our minds about the recent Supreme Court decision on the regulation of the gas industry has been the future construction of gasoline plants or plants to extract liquid hydrocarbons from gas. One of our industry spokesmen, E. H. Selecman of Shamrock Oil & Gas Corporation, has recently speculated that such construction will diminish as long as the decision stands.

Obviously, such plants can justify their economic existence only from earnings from the sale of liquid hydrocarbons and from the sale of the resultant residue gas. If the only sale they would have for residue gas would be to interstate pipeline carriers, he predicts that future gasoline plants so situated will be non-existent.

What operator is going to build such a plant and then have the FPC of his day tell him that the plant is an incident to the sale of gas and that the price at which he sells his gas and gasoline must be regulated and that he shall not be allowed to make more than, say, 6 percent on his investment? Not anyone is going to build a plant of this character for a maximum 6 percent rate.

Furthermore the FPC would not guarantee a 6 percent rate. Such a rate would be predicated upon a test period. It's very possible that the test period would be a period when the natural gasoline prices received at the plant were relatively high. What would happen to the 6 percent return if gasoline prices thereafter dropped below those in the test period? The answer is obvious.

McKetta Back With Refiner

ANNOUNCEMENT of the resignation of Robert J. Phillips, editorial director of PETROLEUM REFINER, to accept an executive position with the Howe-Baker Corporation, Houston, has been made to the editorial staff by Ray L. Dudley, president of Gulf Publishing Company and publisher of PETROLEUM REFINER. Phillips assumed his new duties January 1.

At the same time Dudley announced that Dr. John J. McKetta, who last summer resigned his position as editorial director of PETROLEUM REFINER to return to academic work in a special professorship in the Chemical Engineering Department at The University of Texas, had been named as "Chairman of The Editorial Committee" of PETROLEUM REFINER. In his new capacity, Dr. McKetta, who was editorial director of PETROLEUM REFINER for two years, will retain his special professorship at The University of Texas, but will be active again on PETROLEUM REFINER's staff. Dr. McKetta has never severed his relationship with PETROLEUM REFINER, having been editorial consultant during the last six months of 1954, and retaining his position on the board of directors of The Gulf Publishing Company.

Bob Phillips, a graduate chemical engineer (University of Texas) who came to PETROLEUM REFINER's editorial staff from the refining department of Humble Oil & Refining Company at Baytown with whom he served for four years in various engineering capacities, distinguished himself on PR's staff for his rapid grasp of problems, his initiative, energy and enthusiasm. He carries with him in his new position the best wishes of the staff and management of PETROLEUM REFINER.

5,600,000 new cars in 1955. According to current estimates the automotive industry will build and sell more than five million new passenger cars in 1955. How will your gasolines perform in these new engines throughout the year?

Engineer operates an intricate combination of mechanical, pneumatic, and electronic controls to duplicate road conditions exactly. Here at Ethyl it is possible to create absolutely reproducible tests.

Ethyl Research can help you match your gasoline to the new 1955 cars

What is the best way to be certain that the gasolines you are planning to market this year will give superior antiknock performance in the new 1955 cars—under all driving conditions?

Answer: Look to Ethyl Research.

After twenty-five years' experience in the design, development and improvement of chassis dynamometers for fuel research work, Ethyl Research people have developed three all-weather indoor highways—two at Detroit and the other being constructed at San Bernardino, California. These new test instruments will give you accurate and reproducible knock ratings that have proved far superior to testing on the road.

No traffic impedes the engineers. No sudden shift in the weather upsets the conditions. No shift of crews to other regions for changes in season is needed.

Here in our all-weather rooms, Ethyl research people can control climatic conditions, wind, moisture, temperature and accurately simulate car speeds and road grades. Here experienced crews can work every day of the year, to tell you how your gasoline will behave in the '55 cars on a cold day in Maine, in hot Arizona, in Florida or San Francisco. Every detail of these rooms has been designed to give faster and more accurate evaluation of your gasoline antiknock quality—in any car—under any driving condition.

Here production or experimental fuels can be accurately compared to each other or to standard reference fuels.

These unique all-weather rooms are another example of how Ethyl Research is performing a valuable service to refiners.

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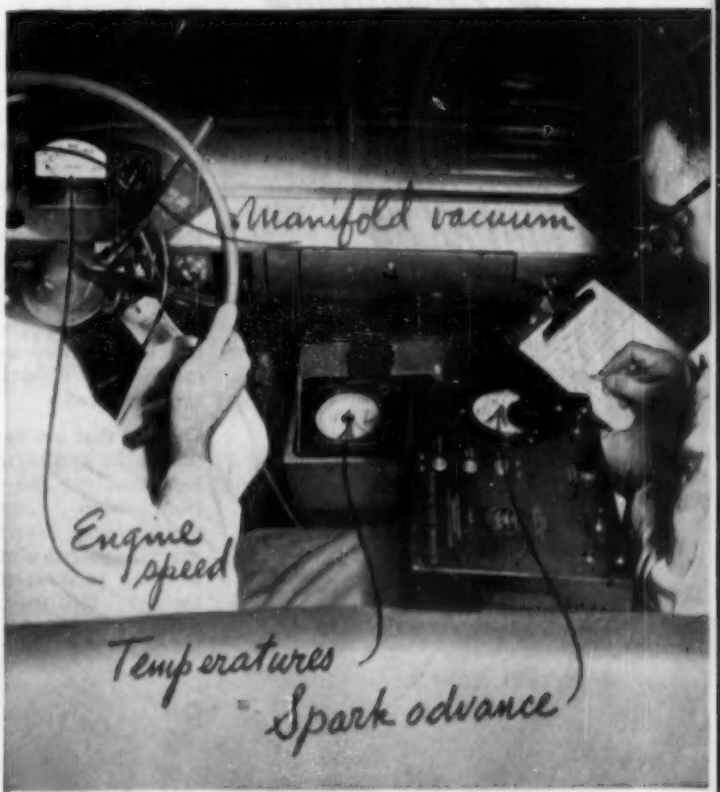
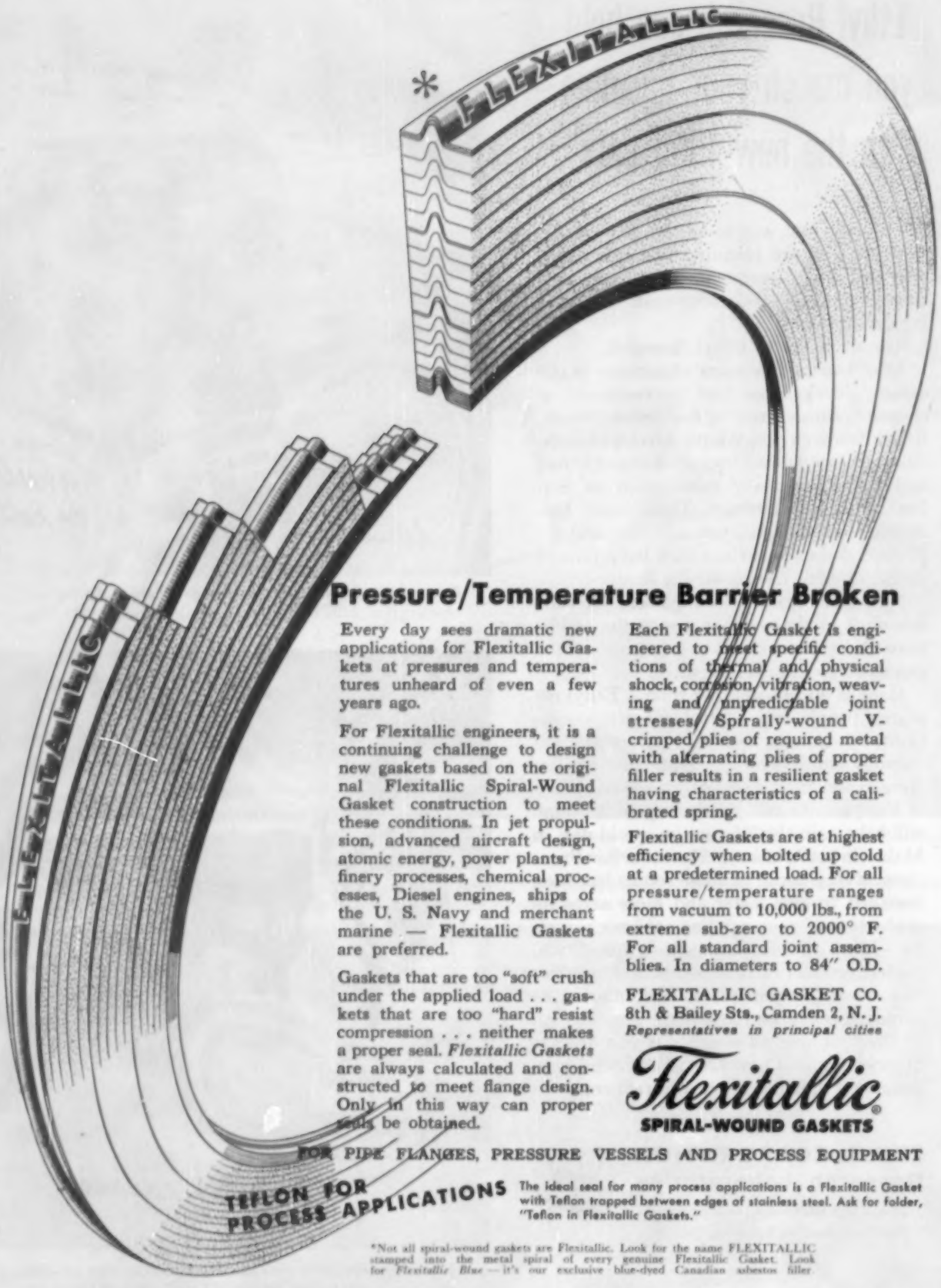
Rear wheels of test car ride on huge rollers that simulate acceleration, hills and other normal driving conditions.



Test engineers check knock and spark advance as car accelerates to "high speed" on one of Ethyl's indoor highways.



Pressure/Temperature Barrier Broken

Every day sees dramatic new applications for Flexitallic Gaskets at pressures and temperatures unheard of even a few years ago.

For Flexitallic engineers, it is a continuing challenge to design new gaskets based on the original Flexitallic Spiral-Wound Gasket construction to meet these conditions. In jet propulsion, advanced aircraft design, atomic energy, power plants, refinery processes, chemical processes, Diesel engines, ships of the U. S. Navy and merchant marine — Flexitallic Gaskets are preferred.

Gaskets that are too "soft" crush under the applied load . . . gaskets that are too "hard" resist compression . . . neither makes a proper seal. *Flexitallic Gaskets* are always calculated and constructed to meet flange design. Only in this way can proper seals be obtained.

Each Flexitallic Gasket is engineered to meet specific conditions of thermal and physical shock, corrosion, vibration, weaving and unpredictable joint stresses. Spirally-wound V-crimped plies of required metal with alternating plies of proper filler results in a resilient gasket having characteristics of a calibrated spring.

Flexitallic Gaskets are at highest efficiency when bolted up cold at a predetermined load. For all pressure/temperature ranges from vacuum to 10,000 lbs., from extreme sub-zero to 2000° F. For all standard joint assemblies. In diameters to 84" O.D.

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*Not all spiral-wound gaskets are Flexitallic. Look for the name FLEXITALLIC stamped into the metal spiral of every genuine Flexitallic Gasket. Look for *Flexitallic Blue* — it's our exclusive blue-dyed Canadian asbestos filler.

Who's Building . . .

CONSTRUCTION BOXSCORE starts on page 186

CALTEX refinery at Batangas: First for the Philippines.

Caltex Opens Batangas Refinery

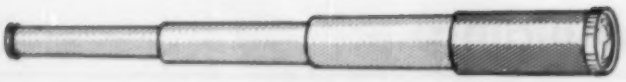
New $30 million installation, first for the Philippines, will process 13,000 barrels of crude per day.

PRESIDENT OF the Philippine Republic Ramon Magsaysay officially opened the new Philippine oil refinery of Caltex (Philippines) Inc., last month. In his talk at the inaugural ceremonies, attended by government and local officials, business leaders and Caltex Group officers, Magsaysay stressed the importance of the new plant to the Republic's economy.

The $30 million refinery is the first for the Philippines. Built and owned

See PHILIPPINES' FIRST and
More Construction Items
Page 177

MAIN process units include this crude unit and fluid catalytic cracking unit.

What's Ahead  1955—

Industry Leaders Predict Good Year

Big problems are federal control of natural gas and balance of supply and demand.

DISSOLUTION OF two immediate problems will bring industry some rich rewards during the new year:

Earnings will stand up.

Crude and gasoline prices likely will remain stable.

Gasoline inventories can be improved.

Proration will be less stringent.

These are the majority opinions of six presidents or board chairmen who participated in PETROLEUM REFINER'S annual symposium on prospects for the new year. Those who contributed their opinions are T. S. Petersen, president, Standard Oil Company of California; James C. Donnell II, president, The Ohio Oil Company; Robert G. Dunlop, president, Sun Oil Company; L. F. McCollum, president, Continental Oil Company; J. S. Leach, chairman, The Texas Company; and Reese H. Taylor, president, Union Oil Company of California.

But there is a sobering note in their composite predictions. The promised rewards hinge to a degree upon the outcome of these problems:

- Government interference must be thwarted through upset of the Phillips ruling in an impending congressional fight.

- Supply and demand must be brought into balance. Some of the executives specifically pointed to the necessity of healing the family rift over imports, though they disagreed as to the remedy.

There were other challenges pointed out in answer to this question:

What are the two most important problems facing the oil industry during the coming Year?

Petersen—The freely competitive atmosphere which has existed in the past for petroleum and natural gas is now seriously threatened by federal control on natural gas as a result of the Supreme Court decision in the Phillips case. It is essential to contiuance of ample supplies for consumers in the future that this decision be nullified by appropriate legislation by the Congress.

Excess producing and refining capacity, for a national emergency, attained at federal government request by the industry at the latter's own expense, constitutes a sizable problem if we are to avoid periods of uneconomic production of crude oil and products.

Donnell—The industry's primary task during 1955 is to obtain an amendment to the Natural Gas Act in order to restore the freedom which is needed for insuring an adequate and continuous supply of oil and gas. Federal regulation of natural gas sales at the wellhead can't help but lead to conflict and confusion between and among the Federal Power Commission, the various producing states, and the thousands of units in the industry. While its net tangible result will be an adverse effect on the supply of natural gas, the moral issue is much more compelling as a force for uniting oil and gas producers in demanding release from federal control. In the forthcoming struggle, producers should be strengthened by the knowledge that they are fighting for the preservation of fundamental principles which have made the U. S. great.

Dunlop—The two most important problems facing the industry during the coming year are: (a) limitations upon economic freedom by government, and (b) restoration of petroleum supply and demand equilibrium.

(a) Encroachments upon economic freedom have taken place in the area of price making (regulation of prices for natural gas sold by independent producers in interstate commerce for resale, and price inequities resulting from the operation of toll road authorities); and in the area of marketing structure (divorcement proceedings against integrated oil companies, and exclusive dealing litigation).

These inroads into competitive freedom have, in effect, denied two basic economic truths: first, that the lowest possible price to the consumer consistent with the best employment of productive resources can result only from the action of many individual units in a freely competitive system; and second, that the most effective and lowest cost distributive system is the one that evolves when competitors strive for maximum efficiency in a free market.

(b) During the past several years, in the interest of national defense, the industry has built more producing and refining capacity than would have been called forth by normal economic demand, thus raising the problem of excess capacity. So long as international tensions makes this necessary, a major problem will be one of adjusting the supply rates (within the framework of excess capacity) to the more moderate increases in demand that are anticipated.

McCollum—The two most important problems facing the oil industry during the coming year are:

A. The issue of federal control over the production of natural gas. This matter is of vital concern not only to the industry but to all the natural gas consumers in the country, because the finding and developing of the future

ROBERT G. DUNLAP L. F. McCOLLUM J. S. LEACH REESE H. TAYLOR

supplies of gas are threatened.

B. The attainment of a proper balance between supply and demand. This problem is being aggravated by the rapid increase of foreign production which reduces export of petroleum products from the U. S. and causes extra pressure for the importation of crude oil and products into the U. S. The immediate solution of this problem appears extremely difficult.

Leach—In reviewing the outlook for next year, we believe that there are three paramount problems facing the industry, all equally important:

1. *Depletion allowance.* The continuing effort to reduce or eliminate the percentage depletion allowance threatens the ability of the industry to continue its exploration and drilling activity. If the depletion allowance were materially reduced or eliminated, it would result—very shortly—in higher prices for petroleum products, lower demands, and, more important, lower reserves. The industry's inability to continue building its reserves would jeopardize the defense and prosperity of the nation.

2. *Natural gas.* The Supreme Court decision in the Phillips Petroleum case results in a new source of government interference with the oil and gas industry. The new ruling—which empowers the FPC to apply the rigid public-utility type provisions of the Natural Gas Act to production, processing and gathering of natural gas which ultimately moves in interstate commerce—constitutes a direct threat to the development of the nation's gas resources. We think this regulation unwise for several reasons:

- It impairs established contractual rights.
- It discourages further investment in gas development.
- It conflicts with state conservation rulings and orders.
- It results in federal control of oil production.
- It applies public utility concepts to a competitive and speculative business.

We believe that the Natural Gas Act should be amended to except from its provisions the business of producing, gathering and processing natural gas and the resulting sales to those who transport it in interstate commerce.

T. S. PETERSEN JAMES C. DONNELL II

3. *Imports.* The threat of additional restrictions against U. S. imports of petroleum constitutes a menace to the national security, the petroleum industry, and petroleum consumers.

Nearly all foreign crude oil being brought into the U. S. is imported by firms with interests primarily in the domestic industry. The individual business decisions that, in the aggregate, determine the actual level of imports are, in consequence, made in full light of existing domestic requirements and domestic production trends. The record shows that these individual decisions by members of the industry have, in fact, been consistent with strong vitality and growth in the domestic producing industry which, over the years, has established an outstanding record as a "growth industry." This approach has made a vital contribution to America's economic welfare and security by enabling the industry to make flexible

adjustment to long-run trends in America's petroleum requirements and to meet crucial emergency needs for petroleum.

It is clear that any legislative restriction, whether tariff, quota, or some hybrid scheme, would tend to rigidify the level of imports and to eliminate the required flexibility.

Taylor—In our opinion, the two most important problem areas at the present time are related to the imbalance between supply and demand and to the trend toward federal government control of private industry.

Due largely to a general economic readjustment, demand for petroleum products during 1954 has not achieved expected levels. Simultaneously, large imports of low-cost foreign crude oil and the excess refinery capacity built as standby facilities against a possible national emergency have resulted in over-supply. Consequently, inventories became burdensome during 1954. Although progress has been made in solving this problem, it will continue to merit close attention by the industry.

During 1954, the U. S. Supreme Court decided in the Phillips case that the Federal Power Commission had authority to regulate the wellhead price of any natural gas that goes ultimately into an interstate transmission line. Subsequently, the commission has issued an order freezing prices for such natural gas in complete disregard of competitively negotiated contracts between buyers and sellers. Unless this intolerable situation is rectified by legislation, it will seriously retard exploration for any development of natural gas reserves for interstate shipment. This will lead ultimately to inadequate gas supplies, and the previously rapid expansion of interstate natural gas transmission lines to meet customers' needs may not continue. The Phillips decision is but one facet of a trend toward governmental intervention in private industry.

Other important evidences of this trend include the suits instigated by the Department of Justice to divorce integral activities from integrated petroleum companies and the proposals related to "end-use control" of fuel resources. Together these pose a real problem to industry in general and the petroleum industry in particular. The consumer is also threatened, in that success of such attacks on free enterprise would inevitably result in reduced efficiency and higher petroleum product prices.

Will industry earnings stand up?

Petersen—I believe that the industry's earnings will stand up well in 1955.

Donnell—Earnings in 1955 should compare favorably with those of 1954. This conclusion is predicted mainly on an increase in crude oil production and refinery runs to stills resulting from an anticipated demand increase of about 4 percent. Of course, any increase in imports would limit the increase in crude oil production.

Dunlop—On balance, 1955 earnings should be not less than those of 1954.

McCollum—Earnings of the industry in 1955 should be at approximately the same levels as those in 1954.

Leach—The outlook for the industry leads one to expect that earnings in 1955 will be somewhat lower than in 1954 due to rising costs and severe competition.

Taylor—Unless serious unexpected weakness in the U. S. economy should develop we believe that earnings in the petroleum industry next year should be at least comparable to those of 1953 and 1954. The federal tax relief measures of the past year should compensate partially for the less favorable aspect of reduced profit margins.

Will the U. S. gasoline inventories be in balance next spring?

Petersen—Judging from the fact that U. S. stocks are now only about 5 million barrels higher than a year ago, as compared with 20 million or more last summer, I would anticipate that there is a good chance of these not being excessive next spring. However, this is predicated on no overproduction this winter, which could occur if a cold winter should stimulate refinery runs for heating oils.

Donnell—Whether or not the necessary balance in gasoline inventories will be gained by next spring depends on weather conditions. I feel, however, that there is a good chance the balance will be attained and that the price structure will not be markedly different than at present.

Dunlop—Some improvement in the gasoline inventory situation has taken place. The degree to which this trend continues into spring will depend upon how far refiners are able and willing to adjust refinery throughput and product yields as the winter season progresses.

McCollum—Gasoline stocks, which were too high at the end of the driving season in the fall of 1953, were pyramided during the winter, so that they have been well above desirable levels all during the current year. Despite the fact that stocks (as of the end of November) are approaching the levels of a year ago, they continue to be too high in view of current and anticipated demand. Stocks can be brought back into balance by the end of next summer, or perhaps earlier, if each refiner will appraise his stocks in relation to realistic sales forecasts and govern his refinery operations accordingly. This will necessitate self-imposed restraints both as to crude runs and gasoline yields.

Leach—Gasoline inventories will still be relatively high next spring, probably reaching 190 million barrels by the end of March. However, increased demand will tend to reduce the downward pressure on prices.

Taylor—It is expected that inventories will achieve a more economic balance with demand during 1955.

What may be considered the greatest industry accomplishment of 1954?

Petersen—I believe that the promulgation and approval of the Iranian agreement is probably the most outstanding accomplishment.

Donnell—During 1954 the industry managed to bring supply more nearly into balance with demand, an accomplishment which is noteworthy as we enter a new year.

Dunlop—It is difficult to single out any one development as the greatest industry accomplishment of 1954. Unquestionably, however, included in any listing of the industry's accomplishments would be the substantial increase in the quality of motor gasoline which has been

WILLIAM NADEN

E. B. McCONNELL

W. R. ARGYLE

made available to the American motoring public during the year drawing to a close. The motor fuels available to the consuming public in 1954 reached undeniably high standards of quality and have been available to the public at the competitive price levels which have been characteristic of the petroleum industry.

McCollum—The greatest industry accomplishment in 1954 was the continuation of a drilling rate such that the U. S. now has a reserve productive capacity approaching 2 million barrels per day; this provides the American public with a large degree of security, as it exceeds current import rates by about 1 million barrels daily.

Taylor—Probably the outstanding achievement of the petroleum industry during 1954 has been its demonstration of the flexibility of the private enterprise system. During a period of slackening product demand and rising inventories, the industry has been able to expand its production and refining facilities to meet the requirements of a possible national defense emergency without impairment of its financial position and without the assistance of the federal government. Of course, there is a limit to the industry's ability to absorb the financial impact of a permanent over-capacity. If this situation is to continue indefinitely, ways must be found for the industry to earn a return on its defense-inspired capacity investments.

Leach—In my opinion, the settlement of the Iranian dispute was one of the greatest industry accomplishments in 1954. As the agreement is written, it is fair to the Iranian government and to the petroleum industry. We confidently expect that the Iranian solution will ease the tension in the Middle East and will be a strong contribution to international peace.

They See Process Advances . . .

PROCESS ADVANCES will at once constitute the greatest developments and aggravate one of the greatest problems in the refining industry during 1955.

Six refining executives who participated in PETROLEUM REFINER's annual symposium were in the majority both confident and concerned over processes which will result in a capacity for quantity and quality performance beyond current needs.

Participating in the symposium were E. B. McConnell, vice president, The Standard Oil Company (Ohio), Cleveland, who is also the American Petroleum Institute's Vice President for Refining; William Naden, vice president, Esso Standard Oil Company, New York; W. R. Argyle, vice president, Sinclair Refining Company, New York; C. C. Tate, manager, Refining department, Phillips Petroleum Company, Bartlesville; K. E. Kingman, vice president, Union Oil Company of California, Los Angeles; and Walter Famariss, Jr., president Famariss Oil and Refining Company, Hobbs, N. M.

They were asked:

What do you think will be the biggest development in petroleum refining during 1955?

Their replies:

McConnell—I think it is safe to say, perhaps even obvious, that the impact of catalytic reforming will be the major development. As your journals have pointed out, there will be some 50 units in operation during 1955 and more under construction. This development is not limited to large refiners either, as some of the earlier technological advances were in their early commercial operations. Everyone, large and small, will be struggling with the problems incident to integration of a new process into his scheme of operations. Licking the bugs, developing optimum operation conditions, training operators, technologists, and maintenance people, and myriad related activities will occupy the time of refiners.

Naden—The biggest development in petroleum refin-

ing during 1955 is likely to be the establishment on a commercial basis of fluid coking. Coking itself, of course, is an old art but previous methods and processes for carrying out the operation have been expensive and have resulted in rather high yields of coke. Such methods have, therefore, been restricted to areas where fuel oil outlet has been limited with the result that the differential between crude and fuel oil has been quite high.

The fluid process produces substantially lower coke yields with correspondingly higher yields of gas oil which can be used for catalytic cracking. Furthermore, the equipment is comparatively simple with consequent low investment costs. It now appears that this process can be economically justified for most situations existing in this country.

With the commercial establishment of such a process, the refining industry will have a tool which will make it more or less independent of crude gravity and thus permit refining operations for the production of gasoline and other distillate products without being hampered by the necessity of getting rid of fuel oil. In the past excessive fuel oil production has often been the "tail that wagged the dog," but we anticipate that in the future we will not have to face this particular situation with the development of this new process.

Argyle—A forecast of what will be our biggest refining development in 1955 and what will be our biggest refining problem can, to my mind, have but one answer. I would say that the increasingly widespread use of catalytic reforming in the coming months and the resultant capacity for quantity and performance quality beyond current needs will—and should—claim the major attention of petroleum refiners this year.

Catalytic reforming is no longer an infant in the industry. It has been growing rapidly in use. The construction projects announced and under way will shortly bring it to lusty maturity. Its influence already is apparent, and it is at once a great challenge and a great opportunity for the industry.

The highly efficient and economic cat reforming process now makes it possible for refineries of all sizes to readily turn out top-grade products. The availability and the proffered supplies of these products will before long exceed current and anticipated demand.

Unless there is a reasonable degree of restraint by refiners, the industry instead of being the beneficiary of the new instrument may become instead its victim. Prudent economic consideration should counsel refiners to relate operations reasonably to needs.

Most industry people realize what cat reforming means for motor fuel octane production. But perhaps not so well understood is that the free hydrogen released by the process makes possible a somewhat similar improvement in the quality, stability, and real value of "center of the barrel" products, such as home heating fuels, diesel fuels, jet turbine fuels and so forth.

In technical jargon, we refiners can take the side stream distillates of cat cracking and by hydrogenation (using the hydrogen by-product of cat reforming) build back a quality in distillates which otherwise would be attainable only by the straight run distillation process with its limited production.

So, we have in cat reforming a tool for more and better products from the top to the residual part of the barrel.

We must use this tool wisely and economically in the interests of the consumer, the owners, and our own employes. We must use it as an instrument of progress and efficiency, and by moderation and restraint keep it from becoming an instrument of economic destruction.

Tate—The dieselization of trucks, railroads and ships, and the rising importance of the jet airplane for commercial as well as military use has increased the importance of the higher boiling range distillates as engine fuels. In 1955 the industry undoubtedly will direct increasing attention to this important phase of the engine fuel business and to possibilities for significant development of improvements in the quality and a more economical production of such fuel.

Kingman—It is my opinion that 1955 will see a continuation of the present high rate of installation of catalytic reforming facilities. This process has demonstrated its effectiveness in upgrading octane quality of gasoline.

I believe that in 1955 we will also see a greatly increased utilization of the by-product hydrogen resulting from catalytic reforming to improve quality of intermediates and finished products. We know that hydrogen can be used with suitable catalysts to desulfurize gasoline, stove oil and diesel. It can also be used to upgrade cracking stocks and cycle stock. These same catalysts (primarily cobalt-molybdenum) are also effective in removing nitrogen compounds by hydrogenation. The advantages of catalytic hydrogenation on many petroleum fractions are so pronounced that I believe much of the by-product hydrogen from catalytic reforming will be used in this manner. It seems unlikely that we can afford to use by-product hydrogen in manufacture of ammonia and other chemicals. Probably we can afford to generate hydrogen from natural gas to make it available for hydrogenation.

What is the biggest problem the refining industry faces as we enter 1955?

McConnell—There are two areas that appear critical. One is the ever-present problem of earning a sufficient return on refining investments. With the capacity available today—and without getting off into the side issue of what got us where we are—there will be constant price pressure in the wholesale markets for refined products. The upward pressures on costs brought on by quality level requirements of today's automobiles and other fuel-consuming units will continue. The refiners will be in the middle, not an unusual position, but one that requires constant vigilance.

The other area, again not new but serious, is the matter of staffing industry with technologists. In spite of high wage rates and good working conditions associated with the industry, and in spite of the efforts of many industrialists and college administrators, the chronic shortage of competently trained technologists continues. This is aggravated by the general shortage of manage-

K. E. KINGMAN

C. C. TATE

WALTER FAMARISS, JR.

ment talent, since many technologists are absorbed into administrative duties each year and are lost to direct technological effort. It would seem to me appropriate that refiners give a long look in 1955 at their future requirements of technologists and let their imaginations loose on the means to meet those requirements.

Naden—The biggest problem the refiner faces in 1955 is likely to be one of tailoring his operations to fit his sales outlets. This problem has already been discussed at length by a number of people, but it is quite apparent that the solution is not yet clear. With the development of catalytic cracking during the war and catalytic reforming during the last several years, the refiner has replaced his old working tools of thermal cracking and thermal reforming. During most of this replacement period, we have been in a seller's market, in which most every piece of refining equipment was used in an attempt to meet sales requirements. During this period the main object of the refiner was to get the maximum number of barrels of product from his equipment.

The return of a buyer's market and the increase in refining capacity associated with building up a reserve for defensive purposes has put the refiner in a position where he cannot continue to operate his equipment at maximum capacity. Fortunately, the new catalytic refining tools we now have are quite flexible and can be operated in such a manner as to permit the refiner to vary the ratio of gasoline to middle distillate yields over rather a wide range. It is now essential that the refiner learns to develop the extent of the flexibility in order that he can satisfactorily meet his sales requirements without building up excessive inventories of unwanted products.

Tate—The biggest problem for the refiner in 1955 will be to remain competitive in a highly competitive field. He must conduct his operations to produce the highest real quality and lowest cost motor fuel for the consumer. At the same time, if he intends to remain in business he must make a profit. In order to do this he must streamline his production, minimize maintenance, and avoid excesses in the octane race which may only add to expense without creating real value for the consumer.

Kingman—I believe the biggest problem facing us as we enter 1955 is the traditional one which faces refining people; namely, that of operating the complex refinery machinery which we have created to turn out the multitudinous high quality and specialized products which our customers now expect. Refinery operations have become so specialized and technical in nature that no individual can reasonably expect to be conversant with all the ramifications in any large refinery. We require the effective team effort of a carefully selected and highly trained organization to keep this machinery running.

I believe our problem will be to formulate and comprehend the objectives which we must meet and to translate them into terms that the operating team can understand and accomplish.

Famariss—There will be imbalances in 1955. Perhaps the cancer of gasoline wars will cause a financial imbalance. Again, it could be an imbalance of supply caused by gross misjudgment at the management level of high capacity or a selfish maneuver. These and an unknown multitude of others are family problems, none of which have ever failed to find a solution in the entire history of oil refining.

There is a challenge in the calendar of 1955 who has as his accomplice the greatest threat refining and all the oil business has ever faced. It lurks in the deep, insidious shadow of government control. It is fronted by FPC control of gas price at the wellhead. *There* is your threat and *there* is the challenge. It may seem abstract in January of 1955 to visualize bureaucratic control of oil by such innocence, but be not misled. Historical reading will unfold the pattern and it is not as far as you think from unsuspicious innocent encompass to total captivity. Bureaucratic police are not necessarily dressed in military uniform. I fear not the imbalances and problems of our refining industry. Some of us will come out of 1955 wounded, even some as fatalities and others unscathed. Our greatest responsibility is to cut off the initial tentacle of those elements which literally seek to destroy us.

It will be a good game the refining industry plays in 1955, for the team is made up alone of men with the fire of conviction and uncompromising courageousness. We ask no quarter—nor do we wish to give quarter—particularly as regards Washington. ##

What's Ahead **1955—**

What's Ahead 1955—

U. S. Demand to Increase 4.3 Percent

- **Supply is more than ample to meet increase in petroleum product demand.**
- **Jet fuel takes biggest product jump.**

George B. Gibbs,
Refiner Staff

THE PETROLEUM INDUSTRY'S growth will closely compare with the expected 4 percent gain in the American economy in 1955. Four percent doesn't seem like much when compared to years where there's a 10 percent gain (usually in times of national emergency); however, the growth in 1955 will be built on a solid economic foundation, not upon a speculative upsurge or an increase brought by artificial stimuli.[1]

The over-all demand for petroleum products (total domestic and export) in 1954 wound up at approximately 8,115,000 barrels per day—1 percent greater than the record high established in 1953. For 1955, demand will be about 8,466,000 barrels per day—an increase of 4.3 percent over 1954.[2]

To meet this demand, refinery runs to stills during 1955 will be about 4 percent higher—7,279,000 barrels per day. Because the industry has been drawing down excess stocks of gasoline and distillates, runs for 1954 were a shade below those of 1953. Except for gasoline the inventory adjustment has been completed. The two question marks on runs to stills are the weather and further inventory adjustment. The estimates for 1955 have been based on a normal winter. Further, it was assumed that refiners will make more than their usual seasonal shift from output of gasoline to output of distillates. If they don't make this more-than-normal shift, then there will be a shortage of distillates and a glut of gasoline before spring.

The year 1954 was not only an adjustment from the standpoint of inventory but also from the standpoint of capacity. Normal supply and demand conditions in 1950 were disrupted by the Korean crisis. The government asked the industry to establish a security cushion of at least one million barrels a day of excess producing and refining capacity. There was no strictly economic justification for this added capacity, because the market had not expanded to the requested level. The industry did expand even more than this and found itself in 1954 with a 15 percent excess refining capacity. All the expanding done in 1951, 52, and 53 would otherwise have been spread over a period of five or six years. This over-capacity is however no cause for oil industry alarm since any industry as vital as petroleum to the country's security and welfare has to have reasonably spare capacity.[3]

Further, the industry ran its refineries at 75 to 80 percent of capacity before World War II. The curent 85 percent figure is entirely in keeping with history, simply meaning that the industry is a little ahead of the actual current demand.

The increase in the number of automotive vehicles cannot help but increase the domestic gasoline consumption—up probably 3.6 percent over 1954. Also, the industry in 1955 will not be faced with a lessening of military needs as was the situation in 1954.

Kerosine and residual fuels will see only a small increase in demand—1.5 and 2.7 percent respectively; however, distillate fuel oils are expected to increase 8.6 percent. This would be in line with the continuing rise in the number of oil burners in use.

Biggest jump in demand will take place in jet fuels—35.3 percent. Production of jet fuel is now above the level of lubricating oil production and should average about 180,000 barrels per day during 1955. Despite the fact that the military has converted many medium bomb wings and all fighter aircraft to jets, the reciprocating aircraft are far from being dumped.

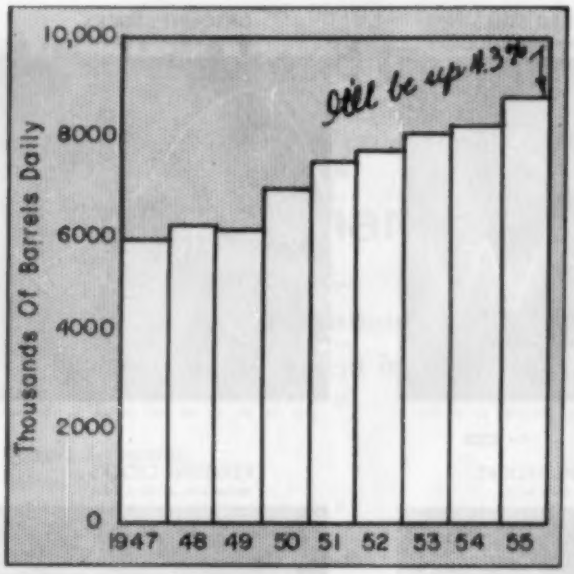
Jets haven't made a dent in civilian airlines yet. They're not expected to, either, until 1958. Even in the foreseeable future, they are to supplement—not supplant—the piston-engine transport.

TABLE 1—Estimated Demand All Oils—1955[2]

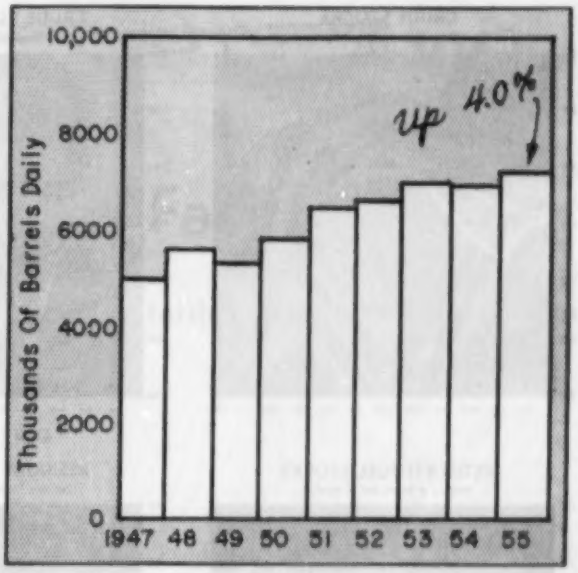
	000 B/D	Percent Change
Domestic:		
Gasoline	3,500	3.6
Kerosine	320	1.5
Distillates	1,560	8.6
Jet Fuel	180	35.3
Residual	1,500	2.7
All Other	1,110	7.3
Total	8,180	5.3
Exports:		
Crude	30	—18.9
Refined Products	250	—18.6
Total	280	—18.6
Total Demand All Oils	**8,460**	**4.3**

TABLE 2—Estimated Supply of All Oils—1955[3]
(000 of B/D)

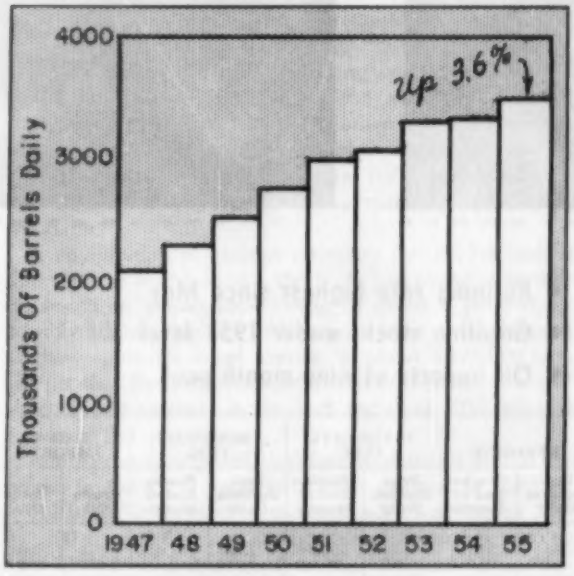
	Estimated 1954	Estimated 1955	Percent Change
Domestic Crude Production	6,388	6,650	4.1
Domestic NGL, etc.	680	720	5.9
Total Domestic Production	7,068	7,370	4.3
Imports Crude Oil	662	710	7.2
Imports Refined Products	402	410	2.0
Total Imports	1,064	1,120	5.2
Total New Supply All Oils	**8,132**	**8,490**	**4.4**



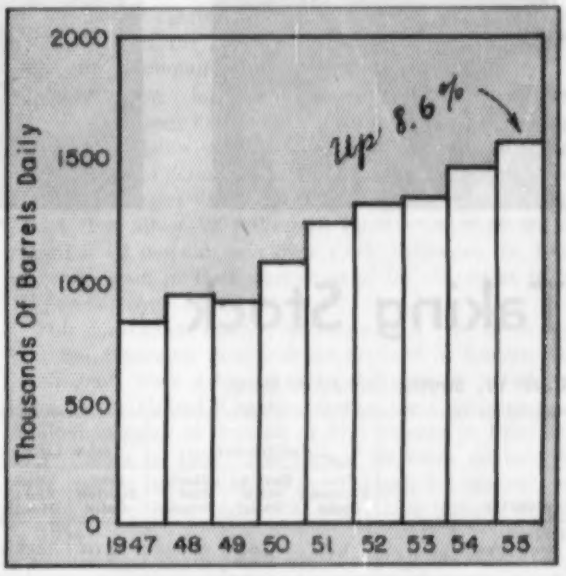
1. Total demand for all oils (domestic and export) supplied by U. S. petroleum industry.



2. Crude runs to stills in U. S.



3. Domestic demand for motor fuel.



4. Domestic demand for distillate fuel oil.

As a matter of fact, the U. S. military requirement for aviation gasoline will reach the peak of 124,000 barrels per day during 1955 and then gradually decrease to approximately 100,000 barrels per day during 1960. Brigadier General White[4] has put a strong case for military aviation gasoline demand as follows: "It is true that every fighter aircraft in the Air Force is now jet propelled, and many of our medium bomb wings are rapidly being converted to B-47 jet bombers. However, on the other side of the ledger—our transports and support-type aircraft are being replaced with larger type aircraft which not only consume more fuel but require grade 115-145 instead of grade 100/130. For example, the B-29 wings, which are being replaced by B-47's, normally consume about five hundred barrels per day, while a wing of the giant transport, such as the C-97 (Boeing Strato-cruiser), consumes about fifteen hundred barrels per day, or about three times the quantity of a wing of the B-29. Another factor which will have a bearing on our future aviation gasoline requirement is the converting of SAC's aerial tankers from KB-29's to the more powerful KC-97's, which are larger consumers of high octane gasolines."

Refiners can expect more foreign crude oil in their runs in 1955. Crude imports will probably increase 7.2 percent, making the supply of crude oil ample to meet product demand. ##

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[3] Rathbone, M. J., Address before 34th Annual Meeting of API, November 10, 1954.
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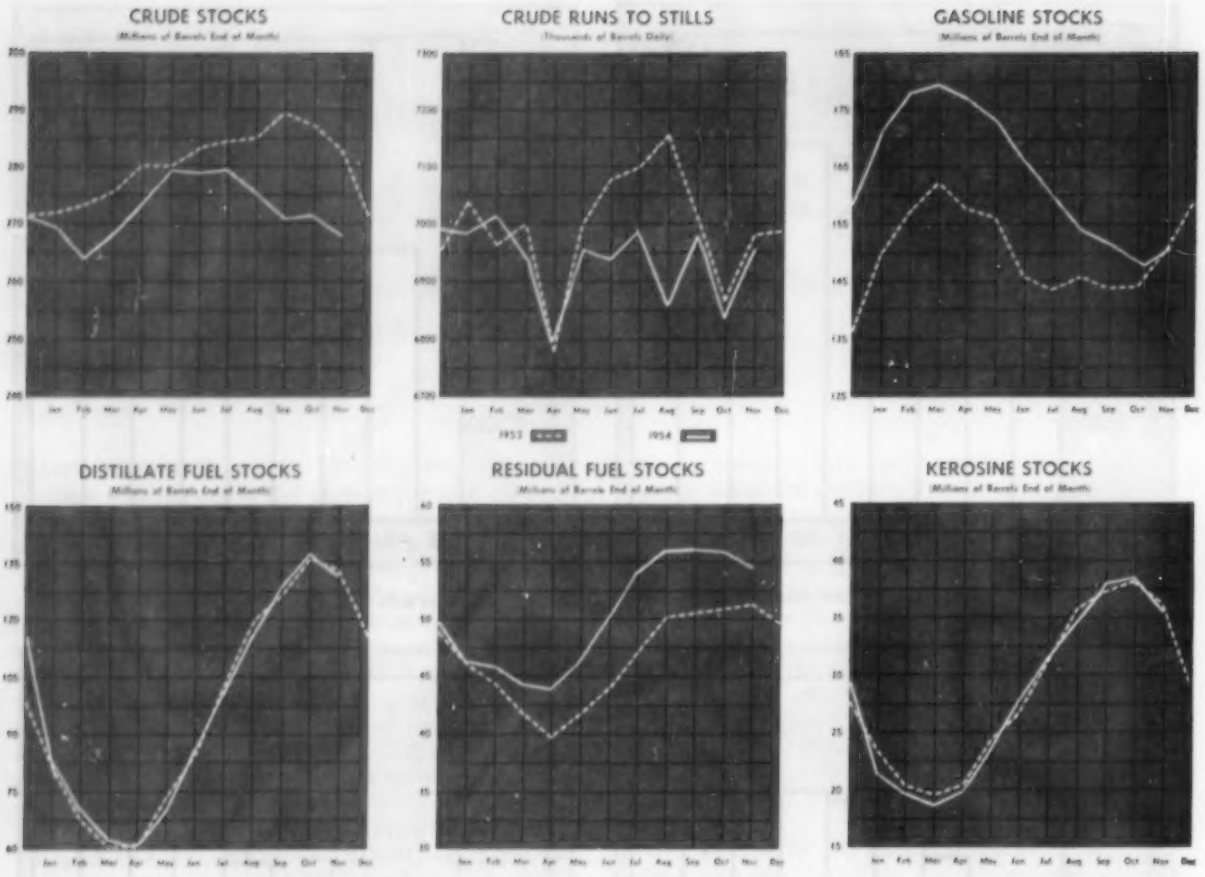

Taking Stock

- Refining rate highest since May
- Gasoline stocks under 1953 level
- Oil imports at nine-month peak

Cecil W. Smith, Economics Editor

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1952:													
November	6,487	7,049	267,852	3,416	129,509	393	32,199	1,510	116,096	1,299	53,069	624	984
December	6,634	6,952	271,928	3,361	136,028	421	26,842	1,509	99,582	1,302	48,706	603	1,165
1953:													
January	6,555	7,042	272,250	3,384	150,518	433	23,292	1,528	80,655	1,307	45,910	616	1,135
February	6,562	6,969	273,589	3,379	157,873	404	20,468	1,505	67,167	1,275	44,178	586	1,066
March	6,531	7,002	275,665	3,319	162,731	359	18,697	1,489	59,802	1,256	41,600	655	1,112
April	6,446	6,781	280,487	3,282	158,032	369	20,335	1,424	61,349	1,219	39,572	628	1,010
May	6,390	7,002	280,308	3,366	156,415	327	24,307	1,400	73,706	1,197	41,795	703	1,096
June	6,595	7,081	283,715	3,467	146,196	326	27,659	1,462	84,504	1,238	43,801	707	1,050
July	6,603	7,103	284,976	3,583	143,916	321	31,143	1,441	102,258	1,224	47,530	629	950
August	6,583	7,163	285,352	3,592	146,050	321	35,711	1,437	119,542	1,222	50,007	672	946
September	6,557	7,023	280,614	3,521	144,184	330	37,280	1,448	126,709	1,203	50,516	692	1,013
October	6,262	6,872	287,541	3,437	144,495	355	38,161	1,462	135,409	1,184	50,820	639	990
November	6,277	6,987	283,021	3,528	150,747	354	36,271	1,463	133,381	1,223	51,267	648	1,120
December	6,238	6,964	276,676	3,628	159,949	378	29,070	1,441	111,944	1,247	49,370	598	1,121
1954:													
January	6,240	6,947	270,811	3,431	171,704	390	22,013	1,467	81,044	1,271	47,474	617	1,143
February	6,379	7,068	266,918	3,476	179,950	412	20,183	1,545	70,390	1,241	47,119	621	1,144
March	6,507	6,923	271,867	3,375	181,297	353	17,533	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,099	56,332	654	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,170	6,838	271,930	3,343	149,603	315	38,214	1,516	137,096	1,053	56,414	660	1,068
November	6,246	6,955	267,642	3,408	150,441	346	35,779	1,573	132,925	1,115	54,851	684	1,107
Week Ended:													
12-17-54	6,268	7,226	265,493	3,497	151,778	357	31,936	1,655	118,082	1,117	52,265	651	1,352
12-18-53	6,248	6,918	277,166	3,365	151,490	345	31,945	1,451	123,214	1,183	49,975	689	1,085

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

What's Ahead 1955—

World Demand Expands Faster

Free world outside the U. S. can expect a further expansion in petroleum demand of about 8 percent in 1955.

Robert S. Spann,
Refiner Staff

PETROLEUM DEMAND in foreign areas continues to expand at a faster rate than in the United States and, sparked primarily by an anticipated high level of industrial activity in Western Europe, the trend of sizable annual increases in demand abroad is expected to continue in the immediate future years barring any major military or political upheavals.

While the U. S. was experiencing a gain in petroleum demand of about 1 percent in 1954 over the preceding year, the growth in demand in other parts of the free world amounted to nearly 9.5 percent. Based on preliminary figures, the volume of demand for all oils reached a new high in 1954, averaging approximately 5,360,000 barrels daily.

A compilation of current estimates for 1955 indicates that the free world outside the U. S. can expect a further expansion in petroleum demand of about 8 percent, or possibly slightly higher. This would boost total demand in these countries to an average of about 5,825,000 barrels per day. By comparison, estimates of domestic demand (exclusive of exports) in the U. S. for all of 1955 indicate a gain of 5.3 percent.

Adding the anticipated 1955 foreign demand to that expected in the U. S. total petroleum demand in the free world in 1955 is expected to reach a level averaging 14,005,000 barrels daily, or an increase of about 6.6 percent over 1954. Including a strictly estimated demand of 1,200,000 barrels daily in the U.S.S.R. for 1955, the world total oil requirement for the year will reach 15,205,000 barrels daily.

The estimated 8 percent expansion in free world demand outside the U. S. for 1955 is believed to be a conservative figure, and if previous experience in the postwar years is any guide, this estimate may be revised upward by mid-year. The trend in recent years has been to greatly underestimate the demand in these foreign areas, especially in the Western European nations. The original forecasts for foreign demand for 1954 were under the actual demand by about the same margin as domestic demand for the U. S. was originally overestimated.

The factors contributing to the unusually high rate of growth in demand abroad generally are the increasing availability of petroleum as a source of energy in nations that had been almost solely dependent upon coal for their fuel requirements in the prewar years; the rapid postwar recovery of many nations that was financed to a large extent by U. S. loans and grants and the continued high level of industrial production in these countries; the rapid growth of refinery capacity in the major oil consuming nations abroad which has lowered the costs of petroleum products and created a new industry in many of these countries; and the intensified competition among international oil companies to supply these foreign markets.

The continued large expansion in demand in Western European nations has been the pace setter in the growing foreign petroleum market. In the first nine months of 1954 European demand—exclusive of Russia and the Iron Curtain countries—increased 14 percent over the like 1953 period. For all of 1954 Western Europe was expected to record a 12 percent gain over 1953. Estimates for 1955 place the gain in European demand for all oils at 10 to 11 percent over 1954.

This contradicts many predictions of a year or so ago that the expansion in petroleum demand in Europe was leveling off after a big surge in the postwar rebuilding boom in the United Kingdom and on the Continent that resulted in gains in demand of 17.5 percent in 1950 and 16.5 percent in 1951. The annual increases declined to more modest margins of 8.9 percent and 8.2 percent, respectively, in 1952 and 1953, but a new upturn started in 1954.

While final figures will not be available for a few months, it is believed the excess of new supply over demand in all of 1954 possibly surpassed the peak level of 456,000 barrels daily reached in 1948. It is difficult this early to predict the trend of new supply for 1955 in foreign areas with any degree of accuracy, but there is ample oil available in all the major producing ares—the Middle East, Venezuela, Canada and Indonesia to meet any probable level of demand with a comfortable margin of safety.

Such a situation, plus keener competition and the return of Iranian production to international trade, has prompted many observers to predict a greater degree of price shading than was experienced in 1954. In the past year, price shading has been limited to refined products and, with the Abadan refinery on stream even at half-capacity levels, there are many indications that price shading will be extended—particularly for residual fuel oil. This trend could easily be extended to crude should refiners' margins be greatly depressed.

What's Ahead 1955—

LPG Demand to Climb

Phenomenal gains in previous years will not be equaled but increase in 1955 should be as good as in 1954.

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SALES OF LIQUEFIED petroleum gas passed another milestone in 1954 with a healthy increase in volume over 1953. The outlook for 1955 appears even better with general upturn of business conditions.

Domestic and Motor Fuel—Sales of LPG for domestic and motor fuel purposes in 1954 are estimated at 3250 million gallons. This represents an increase of 9.2 percent over comparable 1953 sales. As usual the domestic and motor fuel market is the largest segment of total sales and it was gratifying to see this increase where some other industries noticed a leveling-off this year. However, the shorter and milder winter which characterized the winters of 51-52 and 52-53 again prevailed and served to sharply limit larger increases in this category.

The summer sales did not hold up as well as they have in previous years due to the folowing reasons: The usually heavy irrigation load (fuel for the pumping units) did not start until late in the summer; and sales of LPG for tractor fuel were off due to extreme drought which sharply curtailed the use of tractors.

Sales of LPG for motor fuel during 1954 showed exceptional gains over 1953 and if it were to be treated separately in this report would exhibit the largest single category increase. As pointed out last year, it is difficult to separate the quantity of LPG used as motor fuel from the overall domestic use. However, it is conservatively estimated that the sales of LPG motor fuel increased 25 percent over last year. In other words, this use alone amounted to nearly 625 million gallons or over 12 percent of the total sales. There are now more than 2500 buses, 200,000 tractors and untold numbers of trucks and taxicabs operating on LPG. To get the total LPG motor fuel market, one must add that which is used for irrigation, oil and gas well drilling, industrial tractors, lift trucks and refrigeration unit engines in cargo trucks.

Outstanding during 1954 in the LPG motor fuel phase was the interest in converting industrial tractors and lift trucks and engines driving over the road cargo truck refrigeration units.

LPG service stations are becoming a more familiar sight on the highway. ICC has reported that the LPG fuel system is safer than the systems used with either of the other two major motor fuels.

Industrial and Miscellaneous Uses—The sales in this category totalled 382 million gallons—up 2.0 percent over 1953. It is estimated that because of natural gas pipeline extensions or increased pipeline throughputs the industrial LPG load itself was down slightly from last year. This seems reasonable also when one considers that one of the major industrial uses is in heat treating which levelled off last year. However, the increase in miscellaneous applications more than offset the industrial loss so that the net is up. More industrial "standby" plants are being added as a protection against interrupted gas service with consequent shut-down and loss of production. One of the major railroads has stated that propane is an ideal fuel for the gas turbine type locomotive since practically no maintenance is required but they do not contemplate using LPG as a fuel under present conditions of supply, storage and cost as compared with other fuels.

The possible use of LPG for "flooding" oil sands to increase the recovery from low pressure reservoirs containing viscous crude is of considerable interest.

Utility Use—Gas manufacturing demand or utility use of LPG for 1954 is estimated to be about 208 million gallons or 6.5 percent less than 1953. This is due to the mild winter and the natural gas line extensions or increased throughputs. The latter two reasons are, however, the major ones. It should be pointed out that in some areas, the demand for LPG for peak shaving showed sizeable increases due to the utilities taking on new house heating loads. The use of LPG "in the mains" at new housing developments continues to be very popular.

LPG For Chemical Manufacture—Sales of LPG as a

TABLE 1—Marketed Production of LP-Gas

YEAR	Gallons (In Thos.)	Percent Increase	Domestic & Motor Fuel	Percent Increase	Industrial Misc.	Percent Increase	Gas Mfg.	Percent Increase	Chemical Mfg.	Percent Increase	Rubber Components	Percent Increase
1947	2,209,797	20.7	1,150,538	51.7	274,125	3.0	169,332	95.4	414,267	33.0	201,535	—31.4
1948	2,736,801	23.8	1,473,209	28.1	275,883	0.6	237,638	40.3	524,350	26.6	225,641	11.9
1949	2,836,599	3.6	1,627,550	10.5	247,103	—10.4	239,210	0.6	544,886	3.9	177,850	—21.1
1950	3,482,567	22.8	2,022,464	24.3	355,456	—	251,694	5.2	624,468	14.6	228,485	28.5
1951	4,227,275	21.4	2,456,804	21.6	269,408	—	281,692	11.9	844,507	35.2	374,854	64.1
1952	4,477,379	5.9	2,636,736	7.4	338,959	26.0	259,697	—7.8	870,990	3.1	370,997	—1.1
1953	4,932,009	10.2	2,977,418	12.9	374,233	1.04	222,430	—14.4	907,427	11.1	390,501	5.3
1954	5,134,000	4.1	3,250,000	9.2	382,000	2.0	208,000	—6.5	977,000	1.0	317,000	—18.7

raw material for the manufacture of chemicals and chemical intermediates showed only a modest increase of 1.0 percent over 1953, with an estimated volume of 977 million gallons. This increase was brought about by an upturn in demand during the final quarter.

Petrochemicals, as a group, made a much greater gain during the year, but most of the gain was due to increased use of methane and ethane in the production of anhydrous ammonia and polyethylene. Petrochemicals used in the textile industry, many of which are produced from LPG, had a slow year, and the market for synthetic alcohols and various anti-freeze compounds, also large consumers of LPG, was weak. These decreases were slightly more than compensated for by the requirements of new plants and full time operation of plants built in 1953.

Rubber—The demand for LPG as a raw material for the manufacture of synthetic rubber components decreased by more than 18 percent so that the total volume is estimated at 317 million gallons. This reduction in the use of LPG for rubber during 1954 resulted from the substantial cutback in synthetic rubber production authorized by the Federal Facilities Corporation (formerly the Reconstruction Finance Corporation, Office of Synthetic Rubber).

Supply—The production potential of LPG continues to increase despite curtailment in crude-oil production and crude runs to stills at refineries. There were 20 new sources of LPG which were completed or nearly completed in 1954 with a total production potential of over 700 million gallons. This included 19 natural gasoline plants and one major refinery addition. Obviously, this increased capacity was not available for the entire year as some of the larger sources were completed near the end of the year. It is estimated that 15 new plants will be added in 1955 with a product potential of upwards of 200 million gallons. The production capacity is available to satisfy large increased demands for LPG.

Many in the LPG business are wondering how the recently imposed regulation of independent natural gas producers is going to affect their business. Unless Congress acts to remove this regulation, it clearly will be detrimental to the LPG business. Natural gas is just one of the energy products of the petroleum industry which, along with LPG and refined products, compete with each other. About one-third of the natural gas is produced with oil from the same wells. LPG comes from natural gasoline plants which process wet gas to remove the liquids and from refineries processing crude oil. Any regulation which adversely affects the production and marketing of any of these products, all of which share in the cost of exploration, development and production, will tend to increase the cost and decrease the supply of the others. And if the cost of LPG is increased and its supply decreased below market demand level, its competitive position with respect to coal, electricity, and other energy sources is endangered.

Storage—The storage facilities for LPG are at an all-time high. Storage has been increased at all levels—producing, distributing and consuming. It is interesting to note that percentagewise, more tanks are being sold in the 500 and 1000-gallon size. However, with the continued swing to LPG house heating, consumer storage is still too often under-sized to meet the requirements.

The LPG industry in 1954 continued the rapid development of underground facilities for LPG. The 458 million gallons of underground storage in use at the end of 1954 exceeded storage in use a year earlier by 212 million gallons, a gain of approximately 86 percent. At the year's end an additional 250 million gallons of storage was under construction or proposed. This is shown in Table 2.

TABLE 2

Underground Storage for LP-Gas

	Jan. 1, 1954 1,000,000 Gallons	Jan. 1, 1955 1,000,000 Gallons
Storage in Use		
Caverns in Salt Formations	212.1	383.1
Mined Caverns	16.9	27.8
*Storage in Sand Formations	17.0	47.5
Total Storage in Use	246.0	458.4
Storage Under Construction		
Caverns in Salt Formations	93.9	132.9
Mined Caverns	15.8	7.6
Total Storage Under Construction	109.7	140.5
New Storage Proposed		
Caverns in Salt Formations	99.7	92.6
Mined Caverns	20.2	16.8
Total New Storage Proposed	119.9	109.4
Total Storage (In use, under construction and presently proposed)		
Caverns in Salt Formations	405.7	608.6
Mined Storage	52.9	52.2
*Storage in Sand Formations	17.0	47.5
Total	475.6	708.3

* The capacities of storage in sand formations are reported as the maximum volume used thus far as the ultimate capacity is unknown.

Transportation—It is estimated that there are a total of 26,144 pressure tank cars in service suitable for handling LPG. However, about 7500 of these cars are in other service, principally chemical. This would leave an estimated 18,644 cars in LPG service. More than 2100 tank cars were added to the LPG fleet during 1954. Another sea-going barge was christened and put into service this year. This makes a total water fleet of two LPG ships, three dual cargo ships, four propane barges (two inland waterways, two sea-going) and one butane barge. While a substantial amount of the total LPG is currently moved by pipeline, new LPG pipeline projects have been announced for Mexico, USA and Canada. Truck movement is increasing with the trend toward the use of large "blimp type" or single barrel cargotrucks instead of the twin barrel units because of increased payload.

Exports—Sales of LPG for export are up again about 30 percent totalling 38.5 million gallons. New extraction facilities have been proposed for Canada, Mexico and England but are not yet in operation. These plants may affect the export market however the demand is on the upswing and the foreign LPG market is bright.

Outlook—The gain in LPG sales for 1954 was a healthy one although not equal to the phenomenal gains of earlier years.

The house-heating market offers one of the greatest potentials for large volume increases in LPG sales. The motor fuel market is expanding and achieving wider acceptance. It also offers great possibilities for increased volume. The air conditioning field is a growing market for year-around air conditioning using gaseous fuels. ##

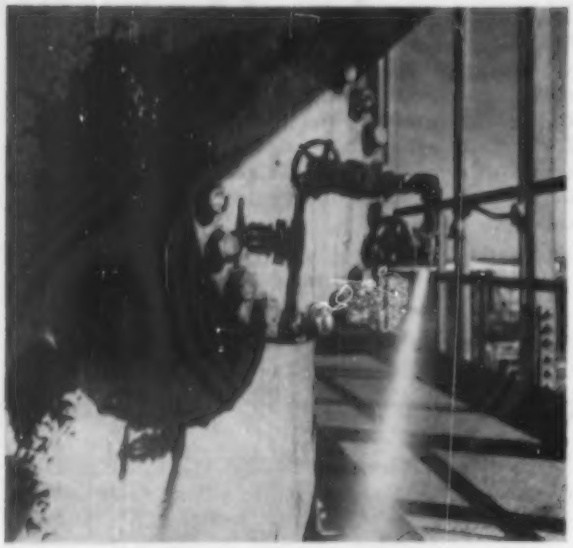

Figure 1. Fog issuing from depropanizer tower.

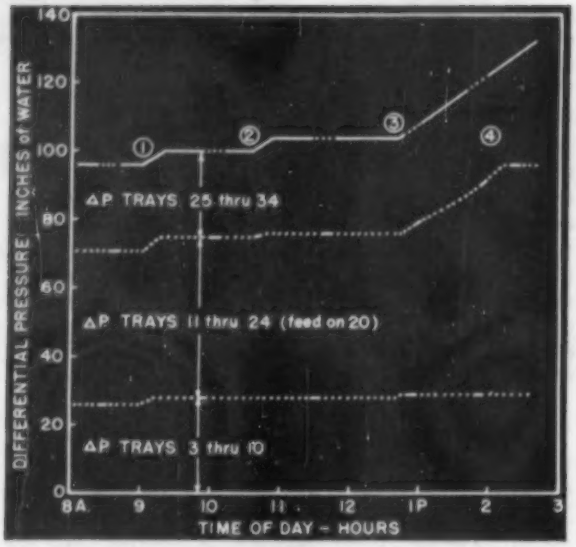

Figure 2—Differential pressure diagram.*

How to Test Fractionators

♦ Part 1. Precise Fractionators

Part 2. Crude Fractionators

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IN THE 30 YEARS that have passed since bubble cap trays came into prominency in the petroleum refining industry, their operation has been studied from every conceivable angle. Prior to World War II most investigators concerned themselves with the ramifications of passing bubbles of vapor thru a boiling liquid or with "hydraulic gradient," that mysterious force that causes liquid to flow across a bubble cap plate. Coincident with our entry into World War II the watch word in the Petroleum Industry became "capacity" rather than "efficiency."

Most of our readers will remember the activities of the Petroleum Industry War Council's Technical Advisory Committee and the campaign for capacity operation of all fractionation equipment in the Petroleum Industry. In addition to serving the war effort, the TAC campaign served to show up the conservative approach that had been taken in the design of bubble cap towers in that a major portion of towers studied was capable of handling 25-30 percent more than design rates and a number of towers handled 100 percent more than design rates.

Since the close of the war several authors have presented design methods based on calculating definite areas for handling liquid and vapor, rather than on selecting a tower diameter based on superficial vapor velocity, adding two feet and then filling up the trays with bubble caps. More recently the fundamental principle of the bubble cap has been under attack and at least five different types of low pressure drop fractionation trays have been described in the literature since 1950. Three of these are comparatively recent developments. One type, the perforated or sieve tray is by no means new but is in the public eye again as a result of being more or less "rediscovered." These low-pressure drop trays have as their one point of similarity the elimination of pressure drop arising from change of direction in the bubble cap. Coupling this reduction in pressure drop on the vapor side with a reduction in resistance to flow on the liquid side affords an increase in capacity over conventional bubble cap trays and the various proponents of these low pressure drop trays report 25, 50 or even 100 percent capacity increase over bubble cap trays. Although these capacity advantages are real they can be attained only by careful process design. In refinery practice most fractionation towers are operated at near capacity rates with liquid and vapor loads somewhat in balance. Under these conditions the expected advantage for the low pressure drop contacting devices would be on the order of 15-25 percent. Higher capacity increases might be attained for special-

STATIC head of vapor can be a significant part of plate pressure drop in a high-pressure tower. This is overlooked in many discussions regarding bubble tray hydraulics.

* (1. Reboiler heat increased at constant reflux by reducing preheat. 2. Reflux increased by increasing preheat at constant reboiler heat. 3. Reboiler heat increased with subsequent flooding of middle section. 4. Liquid build up reaches top section.) (Trays numbered from bottom of column.)

ized operations having abnormal vapor to liquid loading or where the bubble cap trays were not properly designed.

It is the purpose of this article to discuss fractionator tower capacity from the viewpoint of plant test procedures that yield information as to the capacity of a given fractionator tower in a given service. Subsequent sections will describe the techniques that are used for obtaining information in the field as well as the calculations that must be made to evaluate the performance of a fractionation tower. Prior to the discussion of plant test procedures it appears in order to define what is meant by fractionator tower capacity. For a given tower with a given tray layout there are two types of capacities that must be considered, namely the liquid handling capacity and the vapor handling capacity. These capacities are related rather than independent variables and it is necessary to understand the interrelation of vapor and liquid capacities to interpret plant test data.

In a fractionation tower liquid flows down the tower due to the force of gravity while vapor flows up the tower as a result of a pressure gradient from the bottom to the top of the tower. At each plate the liquid meets a series of resistances which must be overcome before liquid can flow to the next tray. These resistances, which consist of the pressure differential across the plate plus the liquid resistances (weir height, hydraulic gradient, etc.) are overcome by building up liquid in the downcomer to the point where the liquid head is equal to the total resistance. It is common practice to express the capacity of a fractionation tower as that combination of liquid rate and vapor rate which causes the height of liquid in the downcomer feeding a particular tray to be equal to the tray spacing. A further increase in either liquid rate or vapor rate will cause liquid to build up on the next higher tray and in a matter of time all of the trays above this point will fill with liquid.

It should be emphasized that flooding starts at one particular point in the tower and the build up of liquid is always experienced on the trays above this point. The trays below this point will continue to operate in a normal manner and, if only a few trays have been flooded, a casual observation of operating conditions will not reveal that the tower is flooded. It is the objective of a plant capacity test program (1) to determine as closely as possible the point in the tower where flooding starts and (2) to obtain heat and material balances which will permit calculation of actual (tower conditions) liquid and vapor rates at the point where flooding starts. Comparison of the actual tray layout which is installed in the tower with a calculated tray layout based on the liquid and vapor rates obtained in the course of the capacity test often points to tray modifications which will permit an increase in tower capacity. This of course is the ultimate objective of most plant test programs. Another phase of a comprehensive test program would involve analysis of a number of tray samples which would (after a bit of calculation) yield data on tray efficiency and optimum feed tray location.

In refinery practice the various fractionation operations can normally be divided into two broad categories —precise fractionation and crude fractionation. This division is based to a large extent on the difficulty of the separation that is to be made and to a lesser degree on the complexity of the feed stock involved. In a majority of the precise fractionation operations the product will contain a maximum of five components and will be subject to a rigorous analysis. In the case of crude fractionators the feed and product streams are wide boiling mixtures in which no individual compounds can be identified and the separation must be defined in terms of boiling ranges. The first article in this series will describe the testing procedures for precise fractionators, while Part 2 will deal with the procedures for towers distilling wide boiling range materials.

A precise fractionator, as the term implies, is one which is operated to obtain a sharp separation between two relatively close boiling materials. Examples of this type of tower are the de-ethanizers, depropanizers, debutanizers, butane splitters, etc. which are found in natural gasoline plants and in the light ends processing areas of refineries. The chief objective of a plant test program is to determine the amount of work that a given tower can do in a given service; that is, what is the maximum charge rate for a certain separation, or what separation can be expected at a given charge rate? In addition, is the column making the separation in the optimum manner, is the feed tray correct, is there sufficient but not excessive reflux? All of these questions are subject to calculation, and must, of necessity, be calculated in design work; however, the process designer uses average data from a large number of towers plus a safety factor to allow for variation from average. The variation of a particular existing tower from the average is unknown, and can be determined only by plant tests. The kinds of tests, the procedure and equipment involved, and the evaluation and correlation of the results will be discussed in the following paragraphs.

Capacity Tests—A capacity test is designed to establish the maximum internal vapor and liquid rates consistent with an operable tower. As stated before, these maximum rates are not independent, but are interrelated such that the liquid capacity is decreased as the vapor rate is increased and vice versa. If the capacity conditions are exceeded, the excess liquid, over and above that which can overflow, will accumulate on the tray until liquid backs up in the downcomer and causes the tray above to flood. This process will be repeated up through the tower until the top plate is reached and liquid runs out through the vapor line. It is entirely possible for a column to run smoothly when it is in a flooded condition, especially if the controlling instruments happen to be in an unflooded section. However, the separation will suffer because of a reduction in tray efficiency due to the poorer phase separation on the flooded trays. In addition, the net bottoms rate will be a stronger function of the overflow capacity of the trays than of the charge rate and the fractionation. In most cases the instrumentation will be such that flooding will cause a great deal of cycling and the tower may become hopelessly out of control. A good capacity test will furnish the information necessary to set operations at peak rates and yet not have frequent upsets. It will therefore make it possible to get the most out of a given fractionation tower.

The basic tools for the capacity test are the heat balance and the material balance. Before starting a

test it is necessary to check the accuracy of all flow meters. This should be done under normal operating conditions when all rates are "lined out." Sufficient data should be taken to write complete heat and material balances around the tower. It is also useful to take charge rate and product rate data on towers that may feed or be fed by the tower to be tested. These data will serve as a check on the material balance and also will give approximate analyses of the products to use in the preliminary heat balance. If the meters are in good condition, the material balance will check within 3 percent. A heat balance around the condenser should also check within 3 percent, while the overall heat and material balance including condenser and reboiler heat loads should check within 5 percent.

Just how is a capacity test done at a light ends tower? The type of capacity test will depend a great deal on the heat exchange equipment available. For example, if the feed is heated by steam preheaters it may be possible to test the capacity of the upper and lower sections of the tower independently. The section below the feed tray can be tested by increasing reboiler heat while maintaining constant reflux and allowing the preheat to decrease. In this manner the vapor and liquid rates above the feed tray remain essentially constant and less than the flooding rates. Thus the capacity of the lower section can be determined without interference from the top section, either by flooding of this section or from lack of condensing capacity. The capacity of the top section can be determined in much the same manner by maintaining reboiler steam constant at some value below the flooding point for the bottom section while increasing reflux and preheat steam until the top section floods. This, of course, assumes adequate condenser surface. If the tower is fed without independent preheat, the increased loading can be accomplished by increasing reflux and reboiler heat. In this case it will be necessary to determine which section of the tower is overloaded. Methods for determining flooding and locating the initial point of flooding will be discussed in subsequent paragraphs.

As the heat exchange capacity is important to tower testing, so is the instrumentation. Before starting the test work, a sketch of the tower should be made showing the instrumentation and types of control that are in force. The location of control points and the position of thermocouples, pressure taps, bleeders, sample points, etc. should be noted. Reference to this sketch will help to solve many instances of peculiar behavior, much of which is due to the reaction of the instruments to flooding rather than to flooding itself.

Now to the actual capacity test itself. It has been found that the accuracy can be improved and the time requirements decreased by making two tests in succession. The first test is a rapid test designed to determine the approximate rates at which the column begins to flood. The second test begins at rates only a few percent below the approximate flooding conditions as found in the first test, and the rates are increased very slowly, taking data when the tower "lines out" after each increase in heat input. For illustrative purposes, let us consider a capacity test on a light ends tower known to have its heaviest loading in the bottom section and using sufficient preheat to permit testing this section independently. Since the loading in the bottom section is to be increased by increasing the heat to the reboiler (constant charge rate), it would be best to put the reboiler steam on rate of flow control, allowing a tray temperature to control the preheat steam. In this way the tester has direct control over the rates in the lower section of the tower. In the first test the reboiler steam rate is to be increased rather rapidly until the tower appears to flood. The increases should be made in small increments, say 1 to 2 percent of the reboiler steam rate, repeated as soon as the column "lines out" again. It has been found that frequent small increases in steam rate are much more satisfactory than large increases at a slower rate because the larger increases will upset the tower to some extent and may require long periods of time for the instruments to bring the column under control again. A 1 percent increase in steam rate can usually be repeated in 15 or 20 minutes, whereas a larger increase may require an hour or more for the tower to regain steady state operation. Once the first test is completed and the flooding point is found to within a few percent, the second test is begun by "lining out" the tower just below the expected flooding point. Again the reboiler steam is increased in increments of 1 to 2 percent but the tower is allowed to reach equilibrium and a complete set of data is taken before the steam rate is increased again. Samples of the feed and of the products can be collected just before the flooding conditions are reached, or if the tower floods before samples are taken the tower can be unloaded again and allowed to "line out" 1 or 2 percent below the flood point for sample catching.

So far we have not discussed how to determine whether or not the column is flooded or where the flooding originates. These may or may not be difficult problems depending on what equipment is or can be made available. In some cases the presence of a flooded condition can be determined by examination of the product rates and the control temperatures. However, these indications usually are not satisfactory for test work for the following reasons:

(1) A small change in product rate may not be readily apparent because of small variations in feed rate or because of variation in product flow caused by control valves.

(2) There is often a long time lag from the time the first tray begins to flood until the control tray floods, especially when rates are only slightly higher than flooding conditions.

(3) Flooding may start above the control tray and tower operation may remain relatively stable even though flooded. If it is necessary to rely on product rate and temperature indications to detect flooding, it may be necessary to wait several hours between increases in tower loading.

A more reliable way to detect flooding is by means of a bleeder in the overhead vapor line ahead of the condensers. The presence of unusual quantities of liquid indicates that flooding has reached the top tray and liquid is spilling over into the vapor line. Here again there is a long time lag between the start of flooding and its detection. In the absence of a suitable bleeder valve a careful heat balance around the overhead condenser will reveal the presence of liquid in the vapor line.

A vapor bleeder above an intermediate tray is a still better method for detecting flooding. The bleeder should be located about half way between trays such that it will be in the vapor space when the tower is operating normally, but submerged in froth and foam when the tray is flooded. If the bleeder is opened during normal operation, a hot gas will come out; however, if the bleeder is opened while the tray is flooded, liquid will spray out, or if the tray liquid happens to be a gas at atmospheric conditions, as is the case in many many light ends towers, the latent heat effect will cause a cold dense fog to appear. Figure 1 shows the fog issuing from a depropanizer tower operating under spilling conditions. U. S. Patent No. 2,467,174 issued to one of the authors describes a "spilling indicator" which records continuously the temperature of the gas flowing through the bleeder valve. A sharp drop in temperature indicates that the tower has started to flood. For quick detection of flooding, the bleeder should be located on the tray that initiates flooding. This tray is seldom known and may not be the same under all conditions. Therefore it is best to have several bleeders scattered throughout the section where flooding is expected. With several bleeders it is possible to determine approximately where flooding starts and to follow its progress up the column.

Another method of detecting flooding is by differential pressure measurement. When a fractionating tray is operating normally, there is a certain pressure drop per tray which is a function of the head lost by the vapors going through the bubble caps, the hydrostatic head of liquid on the tray, and to some extent the static head of the vapor between trays. (A majority of the published papers on tray hydraulics fail to take into account the static head of the vapor. However, this may amount to as much as 30 to 50 percent of the total measured pressure drop in the case of high pressure fractionators.) As the tray loading is increased the tray pressure drop increases also, mainly due to the head loss of the vapors through the caps. However, at the flood point the tray pressure drop continues to increase without further increases in vapor and liquid rates. This is because of the accumulation of liquid on the flooded tray and the subsequent backing up and accumulation on the higher trays. It has been found that when the tray is completely flooded, the tray pressure drop when expressed in terms of clear (no foam) tray liquid will approximate half of the tray spacing. The tower loading corresponding to the flood point can be detected easily with a recording differential pressure meter.

On Figure 2 are plotted typical data from a recording differential pressure meter. This particular meter was manifolded such that pressure drop measurements could be made across several different sections of the tower. The solid lines are actual meter readings. Differential pressures between meter readings have been estimated and are shown as dotted lines. Accumulative pressure drops are plotted; therefore, the difference between two curves represents the pressure drop across one section of the tower. The trays are numbered beginning at the bottom of the tower. The feed entered above tray 20. The following discussion will illustrate the utility of the differential pressure meter in following the behavior of a column during a capacity test. At Point (1) the loading below the feed tray was increased by adding reboiler heat and at the same time the preheat was reduced to maintain constant loading above the feed. It will be noted that the pressure drop increased across Trays 3 through 10 and Trays 11 through 24, while the differential across the trays above the feed remained constant. When, at Point (2), the loading was increased above the feed while retaining constant reboiler heat, the drop across Trays 3 through 10 remained unchanged, the differential across Trays 11 through 24 increased slightly showing the effect of the four trays in that section above the feed, and the drop across Trays 25 through 34 increased substantially. The behavior when flooding is shown graphically beginning at Point (3). The pressure drop across Trays 3 through 10 increased slightly when reboiler heat was added and then remained constant in continued normal operation.

The pressure drop across Trays 11 through 24 continued to increase for some 90 minutes indicating that flooding started in that section. Since the loading above the feed had not been changed, it could safely be said that flooding started at the feed tray or below. (A later examination of the tower internals showed a downcomer restriction three trays below the feed.) At Point (4) the liquid buildup had reached the top of the middle section as shown by the leveling off of the pressure drop across Trays 11 through 24. At that time the pressure drop across the top section began to increase as the liquid buildup continued up the tower. A recording differential pressure meter allows almost immediate detection of flooding. If pressure drop measurements can be made across different sections of the tower, the initial point of spilling can be detected. It is not recommended that any section span the feed tray unless, as was the case in the example, no other pressure taps are available. It is conceivable that the same type of information could be obtained on a low pressure tower by using a calibrated, highly accurate pressure gage.

Other devices which have been used to observe and detect flooding are the sight glass and the multiple tap gage class. The sight glass allows visual observation of the tray and would be extremely useful in determination of the cause and mechanism of flooding, especially if located on the tray that initiates flooding. The multiple-tap gage glass, which is merely a gage glass with the top connected to the vapor space above the tray and the bottom connected to several points on the tray and in the downcomer, can be installed to give flooding point and tray pressure drop information, and, in addition, to yield information on the downcomer hydraulics.

Once the test work has been completed, and the flood point of the tower is established in terms of product, steam, and reflux rates, it is highly desirable to calculate internal loadings and to compare these with various correlations. This is important in that it may be possible to correlate the maximum allowable reboiler steam rate with product rate or comparison might show that the capacity is less than that of similar towers of the same size in which case it might be possible to increase the capacity of the tower with only minor changes.

In order to calculate the internal loadings, it is necessary to know the composition of the vapor and the

liquid on the tray in question. This is easy when dealing with light hydrocarbons because good equilibrium and heat content data are readily available and most analyses can be had on the pure component basis. Knowing the composition of the products and the heat loads it is possible to calculate accurately the compositions of vapor and liquid on any tray, although a stepwise calculation will be necessary. Once the compositions and the weight or mole rates have been established, the actual volume rates can be calculated. Many light ends fractionators operate at elevated pressures, hence it will be necessary to correct the vapor for deviation from the ideal gas laws. This can be done simply by applying a compressibility factor which can be found in many texts and in the handbooks plotted as a function of reduced temperature and pressure. Since tray temperatures are often near the critical for the liquid mixture, there will be a substantial thermal expansion correction to be applied to obtain the actual liquid rate at tray conditions.

After internal rates and densities have been calculated, the capacity of the column can be compared with the capacity as predicted by various correlations. The comparison should be on both limiting entrainment and limiting pressure drop bases. Typical calculations are shown in detail at the end of the section on fractionation of wide boiling range materials. The limiting entrainment calculations should be made along the lines suggested by Souders and Brown[20] and by Atkins[1]. Discussions and formulas for calculating limiting pressure drop are presented by Zenz,[22] Davies,[5] Harrington, Bragg, and Rhys,[12] Brown,[2] and Eld.[7] In applying these calculations to light ends towers the following should be kept in mind: (1) hydrocarbon mixtures, especially wide boiling range mixtures, may exhibit foaming tendencies which are far in excess of those of the usual experimental air-water system; (2) the vapor density in a high pressure tower may be as high as 10 to 20 percent of the liquid density, in which case the effect of vapor static head cannot be neglected in the calculation of total tray pressure drop and height of liquid in the downcomer as has been done in the aforementioned articles on this subject.

Once the calculations have been completed, the limitation to column capacity should be apparent so that the proper steps can be taken to improve operations.

Efficiency Tests — Knowledge of tray efficiency and its variation with tower loading is especially helpful in prediction of separation and in determination of optimum reflux and feed tray location. For accurate results it will be necessary to check all instruments beforehand by means of heat and material balances. If a sharp separation is being obtained the quantity of impurities in the terminal stream will be very small and it will be necessary to have very accurate product analyses to obtain accuracy in the plate efficiency calculation. However, this difficulty can be avoided by taking samples from intermediate trays where the percent of impurity is sufficient to be measured accurately. These samples would be preferably of tray liquid because the amount of entrained liquid present in a vapor sample would be unknown.

There are several methods of varying accuracy for calculating the number of theoretical steps required for a given separation. The most accurate is probably the stepwise procedure outlined by Lewis and Matheson.[14] This method uses equilibrium data and material balance equations to calculate stepwise from either end toward the feed tray. The feed tray is reached when its composition as calculated from the bottom matches the composition as calculated from the top, it being necessary to introduce into the calculations by trial and error those components not present in both products. The optimum feed tray is that which requires the least number of total trays in the tower. In many refineries this method has been adopted for use with the high speed electronic calculator so that the disadvantages of this method in time consumption and chance for arithmetical error are no longer important. In most light ends towers the standard simplifying assumptions can be made without introducing significant error.

There are also several short-cut methods for calculating the number of theoretical steps required for a given separation at a certain reflux ratio. These are usually based on an emperical correlation of required number of steps at total reflux, minimum reflux, and actual reflux such as given by Gilliland[10] and Martin and Brown.[16] The minimum number of steps corresponding to total reflux can be calculated easily by the method of Fenske.[8] The minimum reflux ratio can be calculated with varying degrees of ease by methods proposed by Underwood,[21] Gilliland,[9] or Colburn.[3] The calculation of minimum reflux will usually introduce the largest error into the calculation of tray efficiency by the short-cut methods because actual columns frequently operate only slightly above minimum reflux but with a large number of plates. For such columns the calculated minimum reflux may exceed the actual reflux of the operating tower, indicating infinite tray efficiency which is obviously erroneous. It can be concluded that while the short-cut methods are excellent for rapid design calculations, they are often unsatisfactory for calculating tray efficiency of an actual operating tower especially when the reflux is close to the minimum or when looking for changes in efficiency caused by variation in tray design or operating conditions. ##

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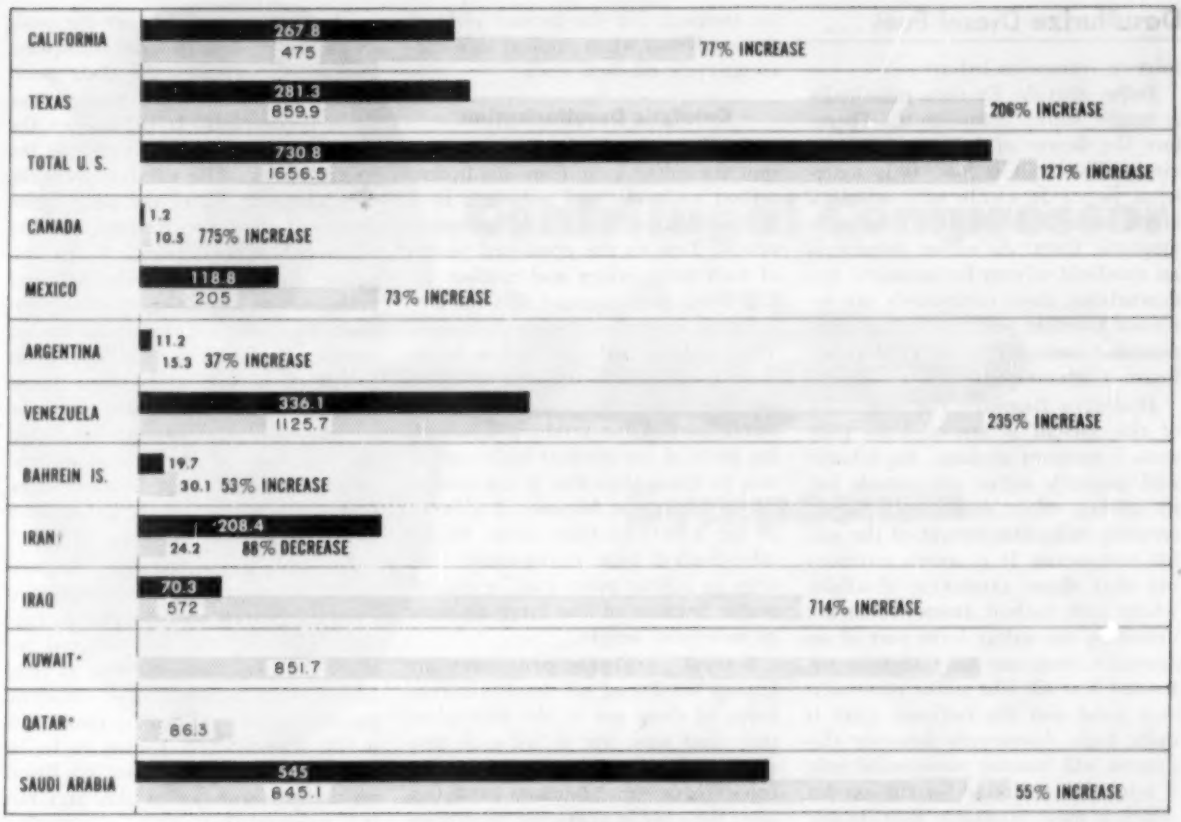
End of Part 1. Part 2 will appear in an early issue.



World production of crudes containing 1 percent or more sulfur: It's increasing every year.*

How to Desulfurize Diesel Fuel

Catalytic processes are becoming more attractive when compared with solvent extraction.

Tibor S. Laszlo, Fordham University, New York

CATALYTIC desulfurization gives greater yields of good quality diesel oil without degrading a large part of the feed to fuel. Instead of removing the entire sulfur-containing molecule (and some sulfurless as well) the molecule is split into the hydrocarbon and sulfur. The latter is removed as hydrogen sulfide, whereas the hydrocarbon adds to the product yield.

The increased consumption of petroleum products brings large quantities of high sulfur crude oils to the world market. The straight run Diesel fuels as well as the cycle oils from these crudes are naturally high in sulfur content. On the other hand diesel engine manufacturers recommend low sulfur fuel in order to avoid excessive cylinder deposit, corrosion and fast deterioration of the lubricant. The petroleum refiner finds himself caught between these two opposite pressures in trying to produce low sulfur diesel fuel from high sulfur crudes. The solution of this problem is the desulfurization of the Diesel oil fractions.

Survey of Processes—The presently known desulfurization processes can be divided into two major groups:

1. Solvent extraction
2. Catalytic desulfurization

Solvent Extraction

Solvent extraction processes are based on the principle of separating the sulfur bearing molecules from the pure hydrocarbons by extraction with a suitable solvent. An ideal solvent would remove all sulfur compounds and none of the hydrocarbons. Needless to say such a perfectly selective solvent is unknown. The best

* Courtesy, *The Kellogg-ram, No. 2, 1954 Series*

solvents recommended are:

Sulfur dioxide. Extracts principally aromatic sulfur compounds. Therefore the degree of sulfur removal in virgin diesel oils is low. It is somewhat better in cycle oils where a larger part of the sulfur is present in aromatic form. As sulfur dioxide is an excellent solvent for aromatic hydrocarbons, these compounds are removed together with the sulfur compounds. Consequently the yield in raffinate is unnecessarily low.

Hydrogen fluoride. The selectivity of this solvent is known from pilot runs. It removes aliphatic, naphthenic and aromatic sulfur compounds but its solvent effect decreases with increasing molecular weight of the sulfur compound. It is worth mentioning that those aromatic disulfides where both carbon atoms which are linked by the sulfur form part of an aromatic ring, are only slightly extracted if at all. The sulfur removal is very good and the raffinate yield is quite high. Apparently however this process will become economical only if a use can be found for the extract which is more profitable than its sale as fuel oil.

Furfural. The selectivity of furfural for extraction of sulfur compounds is better than that of sulfur dioxide but not quite as good as that of hydrogen fluoride. It extracts aromatic and naphthenic sulfur compounds as well as hydrocarbons. The degree of sulfur removal is moderate and so is the raffinate yield.

Table 1 compares the degree of sulfur removal and the extract yield of these solvents when applied to a catalytic cycle oil feed stock.

TABLE 1

SOLVENT	Solvent Volume Percent	Raffinate S Percent	S Removal Percent	Extract Wt., Percent
Sulfur dioxide*	100	0.30	73	26
Furfural	100	0.47	56	25
Hydrogen fluoride	20	0.34	69	14
Hydrogen fluoride	50	0.20	82	16
Hydrogen fluoride	100	0.13	88	17

* Extraction at 68 F.

Catalytic Desulfurization

Catalytic desulfurization processes split the sulfur atom from the hydrocarbon molecule and reduce it in a hydrogen atmosphere to hydrogen sulfide. Due to the combined action of high temperature and catalyst the C-S bonds are ruptured and the free valences saturated with hydrogen. The resulting hydrogen sulfide leaves the system with the by-product gases and the sulfur-free hydrocarbon becomes part of the product. The boiling point of the product hydrocarbon may be lower than that of the mother sulfur compound because of a break in the hydrocarbon chain. In the alkyl-S-alkyl type compounds the drop in boiling point may be considerable because of the large decrease in molecular weight.

Several catalytic processes are known for Diesel oil desulfurization. Some of them are in the pilot plant stage and some are in full scale production. Most of these processes use cobalt oxide—molybdenum oxide catalyst but vary in operating conditions. This variation naturally influences yields, the rate of sulfur removal and the economy of the process. The differences are moderate and will not be considered in this study.

Comparison of Two Processes

The basic difference between solvent extraction and catalytic desulfurization is that the extraction removes the entire sulfur-bearing molecule whereas the catalytic process just splits off the sulfur atom. The importance of this difference becomes apparent in the higher yield of the catalytic process. Furthermore the solvent extraction process removes hydrocarbons which contain no sulfur, thus further decreasing the raffinate yield.

The two processes change the quality of the product in a different way. Extraction increases the pour point by removing some of the natural pour point depressants. It increases the diesel index and does not change the boiling range. The catalytic process, it is claimed, leaves the pour point unaltered, however it does not improve the diesel index. A further, minor disadvantage of the catalytic action is the formation of some light ends. This may require an additional flashing operation if high flash point specifications are to be met. These divergent changes in quality are to be considered in each specific case based on knowledge of the feed stock and product specifications. In most cases, however, economy will be the decisive factor in process selection.

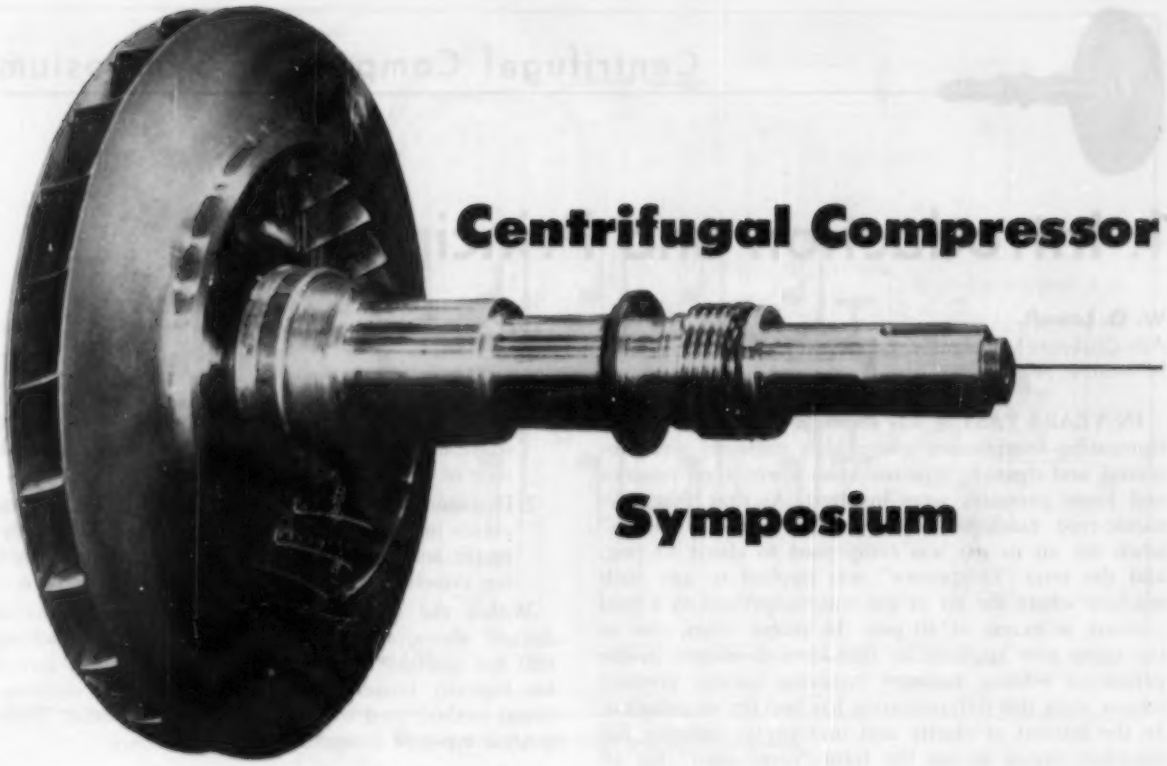
In Table 2 an economic comparison is presented for an unspecified catalytic process and furfural extraction. This solvent was selected because it offers a compromise in yield and sulfur removal. The catalytic process is not specified by name, but a full scale unit is known to be in operation. Yields and costs are based on the performance of this unit but it is believed that results of a similar magnitude would be obtained for other catalytic processes.

The feed stock for both cases is a 0.7 percent sulfur content Middle East virgin gas oil distillate in such quantity, that the raffinate will be 3500 bpcd diesel fuel oil with 0.3 percent sulfur. Investment and manufacturing costs are based on actual data and are in proper relation to each of the two cases. The absolute values may differ widely according to location and changes in the market, but the relative values may be considered constant. The same refers to the price differential allotted to the extract when it is degraded from gas oil distillate to fuel oil.

TABLE 2

	Catalytic Process		Extraction	
Yields:				
Raffinate	99.1%	3,500 bpcd	76.5%	3,500 bpcd
Extract			23.5%	1,075 bpcd
Loss	0.9%	32 bpcd		
Feed Stock	100 %	3,532 bpcd	100 %	4,575 bpcd
Direct Investment Cost	$675,000		$1,765,000	
Manufacturing Cost				
Total Cost	0.270 ¢/gal.		0.699 ¢/gal.	
Price differential for Extract			0.982 ¢/gal.	
Cost: ¢/gal. feed	0.270		1.681	
¢/gal. raffinate	0.272		2.197	

Conclusion—The above calculation shows that the economy of the catalytic process is much more favorable than that of the extraction. Even wide variations in local conditions, such as labor, chemical prices, depreciation, etc., would not reverse this relation. When quality considerations (mainly pour point and Diesel index) are not of paramount importance, a detailed local study of the economy of catalytic desulfurization is well worth while. # #



Centrifugal Compressor Symposium

AS ONE of the newest trends in refinery and petrochemical equipment, the centrifugal compressor has become a part of every modern refinery. The centrifugal compressor is essentially a variable-capacity, constant-pressure machine, as opposed to the positive-displacement compressor which is constant-capacity and variable-pressure. The centrifugal compressor offers the advantages of a wide operating capacity range and low maintenance. It has found wide acceptance in the medium capacity range. There are many considerations which go into selecting a compressor so we have made an effort to cover all phases of this development in seven articles as you will see in the table of contents below.

The Editors

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1. Introduction and Principles

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Milwaukee, Wis.

IN YEARS PAST it was common practice to use reciprocating compressors where high pressures were required, and dynamic type machines where larger volumes and lower pressures were involved. At that time, dynamic-type machines were usually termed "blowers" when the air or gas was compressed to about 40 psig, and the term "compressor" was applied to any such machine where the air or gas was compressed to a final pressure in excess of 40 psig. In recent years, due to the many new applications that have developed in the petroleum refining industry involving various pressure ranges, even this differentiation has become meaningless. In the interest of clarity and uniformity, industry has therefore begun to use the term "compressor" for all types of machines compressing air or gas.

With the term "compressor" being applied to any type of machine carrying out a compression of air or gas, it therefore becomes necessary to more completely designate the exact type of compressor. This can easily be done as only two basic types of compressors exist, as follows:

1. **Positive-Displacement-Type**—Positive-displacement-type compressors are machines in which successive volumes of air or gas are confined within a closed space in which the pressure is increased as the volume of the closed space is decreased.
2. **Dynamic-Type**—Dynamic-type compressors are machines in which air or gas is compressed by the dynamic action of rotating vanes or impellers imparting velocity and pressure to the flowing medium.

Within the two basic categories of compressors as defined above, the various general types of machines that are available for use for petroleum refinery service are logically broken down according to the constructional method used to carry out the compression. These general types of compressors are as follows:

1. **Positive-Displacement-Type—**

A. *Reciprocating Compressors*—are machines in which the compressing element is a piston following a reciprocating motion in a cylinder.

B. *Rotary Sliding-Vane Compressors*—are machines in which longitudinal vanes slide radially in a rotor mounted eccentrically in a cylinder. (See Figure 1)

C. *Rotary Lobe Compressors*—are machines in which two mating lobed impellers revolve within a cylinder, and are prevented from making contact with

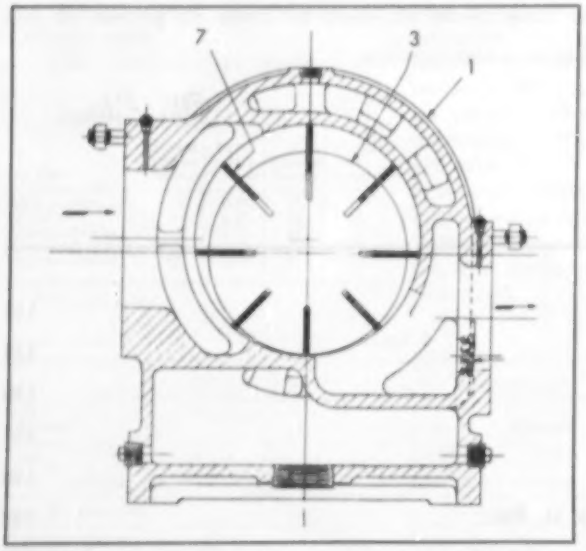

Figure 1. Cross section of a single stage water cooled rotary sliding vane compressor. Part 1 is the cylinder, Part 3 is the rotor and Part 7 indicates the sliding vanes.

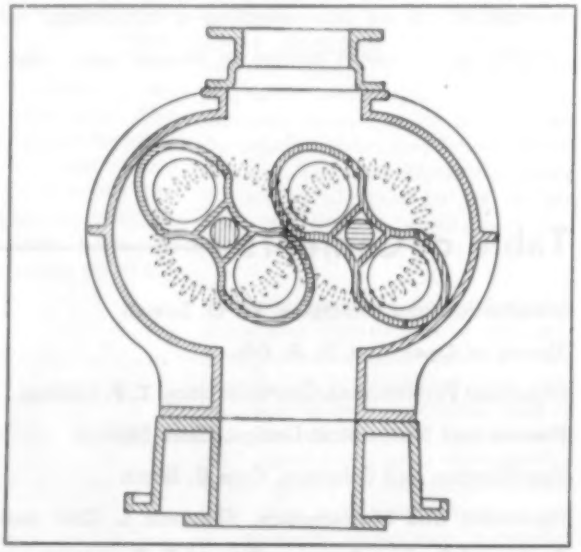

Figure 2. Cross section of a lobe type compressor. (Figures 1 and 2 by permission from *Compressed Air Handbook*, 2nd Ed., Compressed Air and Gas Institute. Copyright 1954. McGraw-Hill Book Co., Inc.)

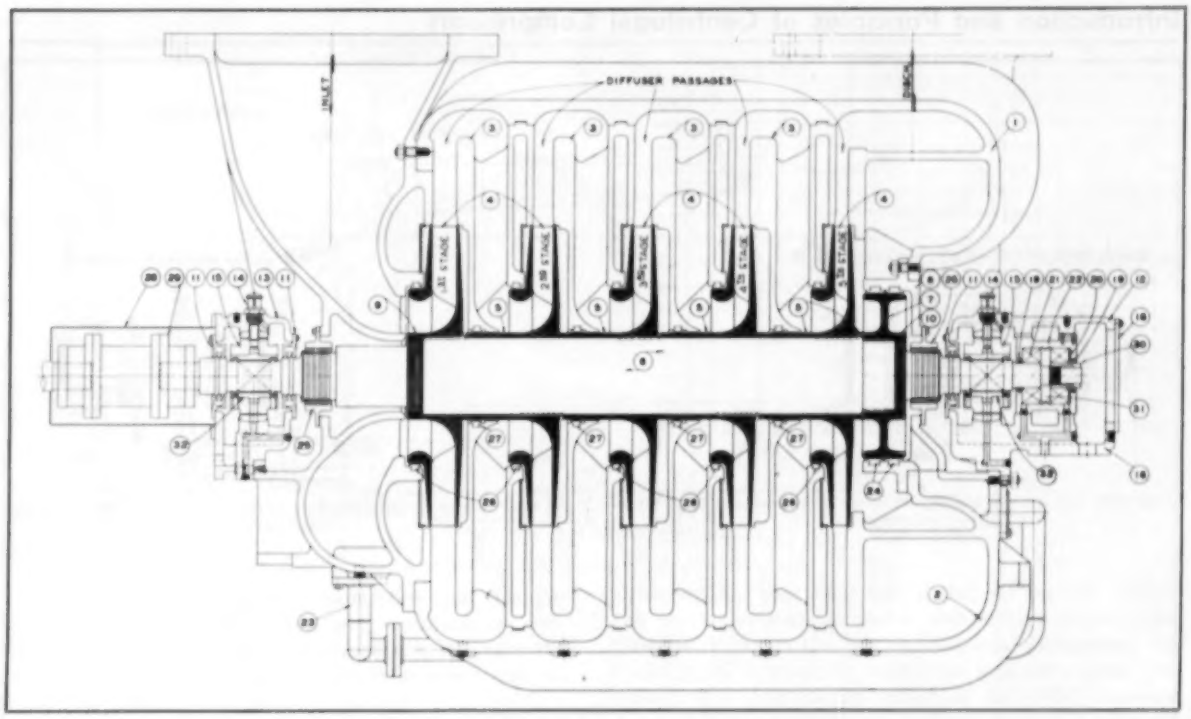

Figure 3. Cross section of a five stage centrifugal compressor

(1. Blowing casing—upper half; 2. Blower casing—lower half; 3. Diaphragms; 4. Impellers; 5. Shaft sleeves; 6. Main shaft; 7. Balance piston; 8. Balance piston sealing gland; 9. Locknut—L.P. end; 10. Locknut—H.P. end; 11. 4¼" oil baffle; 12. H.P. bearing cover; 13. L.P. bearing cover; 14. Bearing oil vent; 15. 4" x 6" load bearing assembly; 16. Bearing housing H.P. end; 17. Bearing housing L.P. end; 18. Bearing end cover; 19. Thrust bearing seal ring; 20. Thrust bearing filler piece; 21. Kingsbury JHJ-7 thrust bearing; 22. Thrust bearing housing; 23. Balance piston equalizing pipe; 24. Balance piston sealing ring; 25. Shaft air baffle-L.P. & H.P. end; 26. Impeller sealing ring; 27. Shaft sleeve sealing ring; 28. Coupling guard; 29. No. 3½ fasts coupling; 30. Thrust bearing collar locknut; 31. Thrust bearing collar; 32. Bearing liner.)

each other by timing gears mounted outside the cylinder. (See Figure 2)

D. *Rotary Liquid-Piston Compressors*—are machines in which water or other liquids are used, usually in a single rotating element, to displace the air or gas handled.

2. **Dynamic-Type**—

A. *Centrifugal Compressors*—are machines in which velocity and pressure are imparted to the air or gas in a radial direction by one or more impeller-diffuser combinations. (See Figure 3)

B. *Axial Compressors*—are machines in which velocity and pressure are imparted to the air or gas in an axial direction by one or more sets of moving and stationary rows of blades. (See Figure 4)

Since all air or gas compression machines are now being termed "compressors," proper identification of equipment necessitates that the specific type of compressor, as outlined above, be included in referring to any compression machine to avoid misunderstandings. Usually, it is not difficult to determine the compressor type best suited to a specific job of compression because each type has its own distinguishing characteristics and advantages.

Although each of the positive-displacement types will vary from the other somewhat they can be grouped together as a single class of machine for the purpose of comparison with the dynamic-type of compressors. In comparing the basic performance characteristics of positive-displacement and dynamic-type compressors, Figure 7 shows the general type of pressure—capacity constant speed characteristics of the three types of machines. The centrifugal compressor is essentially a variable-capacity constant-pressure machine and the axial compressor and the positive-displacement compressors are essentially constant-capacity variable-pressure machines.

These basic characteristics, however, represent only part of the comparison problem of choosing which type of compressor is best suited to a specific application. Of equal importance is the inherent capacity range that can be built into a single machine. As a general rule, it can be stated that positive displacement machines are for small capacities, centrifugals for medium capacities and axials for large capacities per machine. Like all other general statements, however, it must be realized that there is considerable overlapping of capacity range between these different types of compressors.

Considering the small capacity positive displacement and the medium capacity centrifugal machines, several general points of comparison can be made as an aid to proper application. The reciprocating compressor, which is widely used in refinery service, will be used as the representative positive displacement machine in this comparison.

The reciprocating compressor is usually a small capacity high pressure rise machine. It has the positive displacement compressor characteristics in that the den-

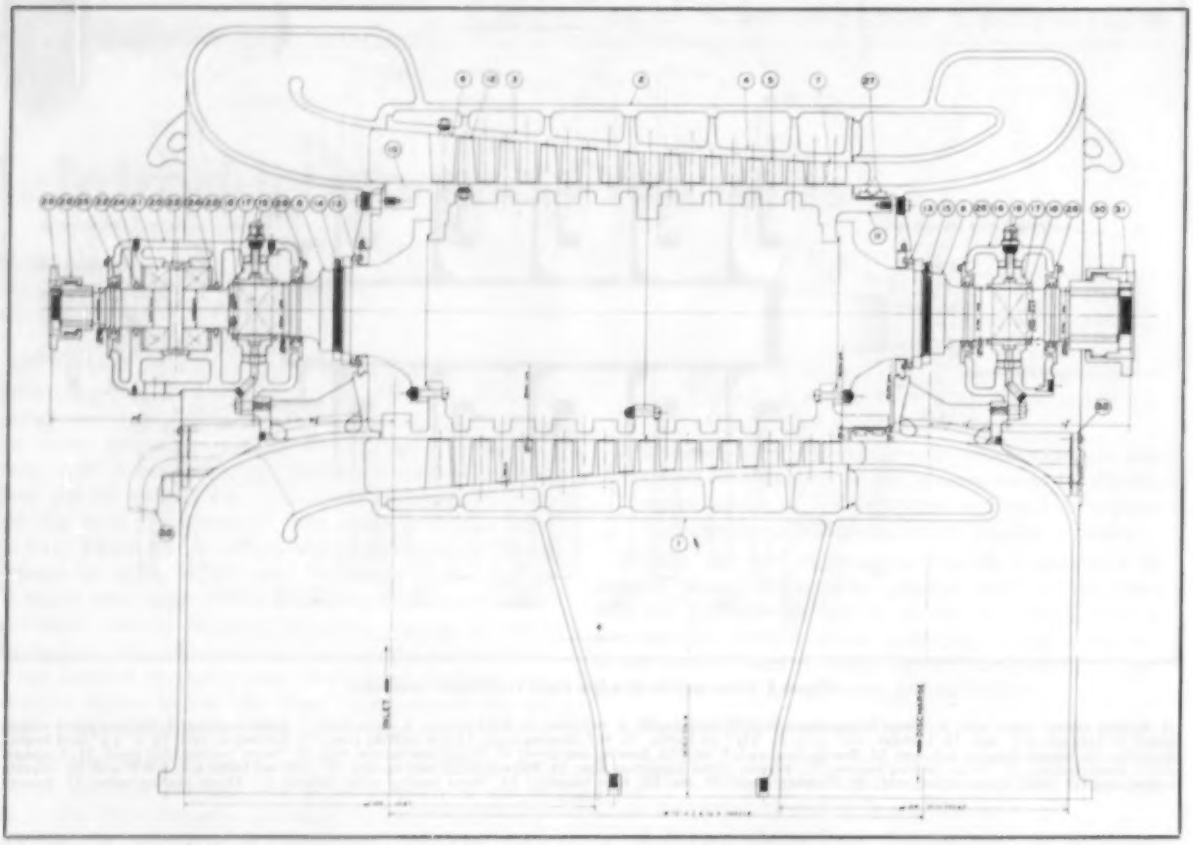

Figure 4. Cross section of a nine-stage axial compressor.

(1. Casing lower half; 2. Casing upper half; 3. Front stator; 4. Rear stator; 5. Stator blade; 6. Inlet guide vane; 7. Straightener vane; 8. Rotor stub inlet end; 9. Rotor stub Disch. end; 10. Front Rotor body; 11. Rear Rotor body; 12. Rotor blade; 13. Shoulder seal assemble; 14. Seal locknut L.H.; 15. Seal locknut R.H.; 16. Load bearing housing; 17. Bearing shell; 18. Bearing liner; 19. Bearing oil vent; 20. Load & thrust bearing housing; 21. Kingsbury thrust bearing JJ; 22. Seal ring; 23. Oil control ring; 24. Filler piece; 25. 6 dia. oil baffle; 26. 8 dia. oil baffle; 27. Seal ring for bal. piston; 28. 4½-A Waldron coupling—(spacer type); 29. Coupling locknut L. H.; 30. 6-S waldron coupling—(spacer type); 31. Coupling locknut R.H.; 32. Equalizing pipe.)

sity of the gas compressed has no effect on the pressure rise since the pressure rise is obtained in the cylinder by positive compression through movement of the piston. A constant speed reciprocating compressor will therefore provide the same pressure rise when handling gases of varying molecular weights. This characteristic simplifies the selection of a reciprocating compressor over a centrifugal for which gas density range is a vital design factor.

This positive compression can also be a handicap since destructive pressures can be built up by a reciprocating machine if the capacity of the compressor is too large. With a centrifugal machine, this danger does not exist as these machines have a wide capacity range and will go into the condition known as "pumping" or "surging" at capacities below that range.

The cylinder and piston type of construction of the reciprocating compressor lends itself to the design of small capacity machines because low gas velocities and slow speeds can be used. On the other hand, the centrifugal compressors utilize much higher gas velocities as the actual means of producing pressure rise. Since these gas velocities are a function of the impeller tip speeds, expressed in feet per second, smaller capacities call for impellers operating at reduced diameters and correspondingly higher rotative speeds to maintain proper tip speeds. Rotative speed in revolutions per minute as well as impeller width in centrifugal compressors become limitations in small capacity machines.

For the other side of the picture, reciprocating compressors for large capacities become excessively large due to lower gas velocities and piston speed limitations. These larger machines with the high reciprocating inertia loads of their pistons, mean more expensive foundation both in floor space and in mass than are required for the smaller rotating centrifugal machines.

The final general comparison is in operating economy. As a general statement, again, the centrifugal machine requires less maintenance than a reciprocating compressor. This advantage is due to the absence of rubbing parts in the centrifugal design such that it can operate for a longer period between maintenance shutdowns. In actual operating efficiency, the reciprocating compressor is somewhat more efficient than a comparable sized small centrifugal if both are designed for the same capacity.

The break-off point where one type is selected over the other must therefore be determined by the total

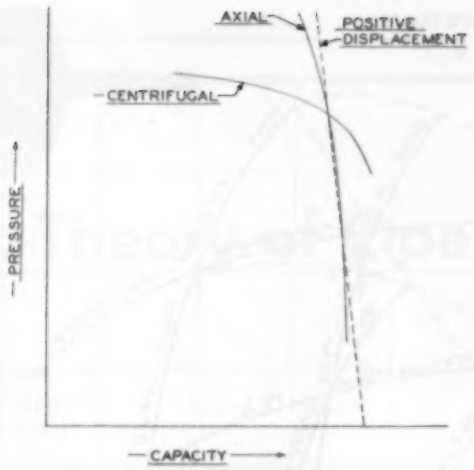

Figure 5. Comparison of full speed characteristics of various types of compressors.

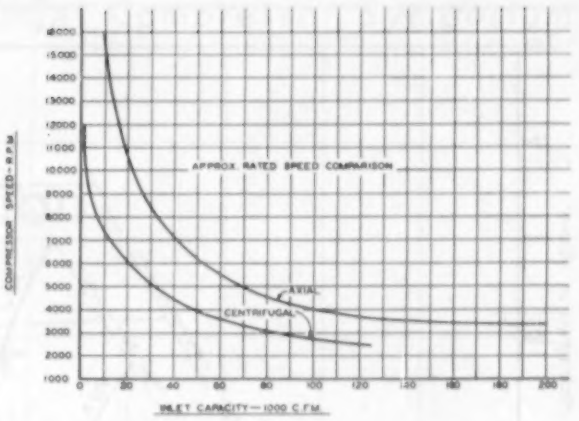

Figure 6. Approximate rated speed comparison of axial and centrfigual compressors.

analysis involving initial cost, foundation and installation cost, operating efficiency and maintenance cost. The trend, however, is toward centrifugals wherever the capacity, pressure and gas density conditions can be fitted into existing designs.

Now turning to the medium capacity centrifugals and the large capacity axials, the centrifugal has the advantage of a natural wide capacity operating range whereas the axial has higher operating efficiency. Reference to Figure 5 will show the comparison of the full speed pressure—capacity characteristic curves for each of these types.

As a rule of thumb, it can be said that an axial compressor will have approximately twice as many stages as a comparable centrifugal for the same pressure rating. Reference to Figures 3 and 4 will show that a stage of a centrifugal blower consists of an impeller, a diffuser and a return passage leading to the next impeller, whereas a stage in an axial compressor consists of a row of moving blades and a row of stationary blades.

Figure 6 shows the approximate rated speed characteristic of both axial and centrifugal compressors at various capacities. The axial compressor inherently operates at a higher speed than a comparable centrifugal because of the "straight-through" blade path of the axial compared with the radial velocity-pressure conversion in the centrifugal. It should be kept in mind, however, that the speed-capacity curves shown are only average representative values for the size of machines required and design modifications can be made to permit a variation in design speeds from those shown.

With the higher operating speed of the axial compressor, it is physically smaller than the comparable centrifugal. This factor combined with the approximate 3600 rpm design speed at the capacity range where the slower speed centrifugal is reaching its capacity limit, favors the use of the axial for large capacities.

The axial compressor is not new to the petroleum refining industry. It has seen service for over seventeen years in conjunction with the gas turbine furnishing air for pellet-type catalyst regeneration. With the advent of the fluid catalytic processes, excessive catalyst carry-over prevented the continued use of the gas turbine drivers and the trend went to motor and turbine driven centrifugals. Without the gas turbine-axial compressor set available for application under the new conditions, the industry felt that the advantage of the wider capacity range of the centrifugal more than offset the extra efficiency of the axial compressor.

Design improvements on axial compressors in recent years, however, have brought forth modifications that merit their careful consideration where larger capacity compressors are required. Refinements in blade shape have cut the rows of blades required for a given compression in half. In other words, an axial compressor of the design used prior to World War II used twenty stages to obtain a pressure rise that present day designs can achieve with ten stages.

Another present day feature that is of great importance is the use of blades that are mounted in such a manner that the pitch of the blades can be varied after the machine has been built. This variation in blade pitch has a marked effect on the capacity of the axial compressor. This means that a present day axial can be adjusted to meet a wide range of capacity conditions at high efficiency without requiring new blades.

The latest axial compressor advancement is the use of stator (cylinder) blade pitch changing mechanism that will permit the change of the angle of all or part of the stator blades in the axial compressor while the machine is in operation. This blade angle change provides a capacity range for the axial compressor of approximately the same magnitude as has been obtained from the centrifugal compressor. The usual high axial compressor efficiency is retained with this stator blade angle change.

Figure 7 is a chart comparing the pressure-capacity characteristics of an axial compressor with automatic

Centrifugal Compressors

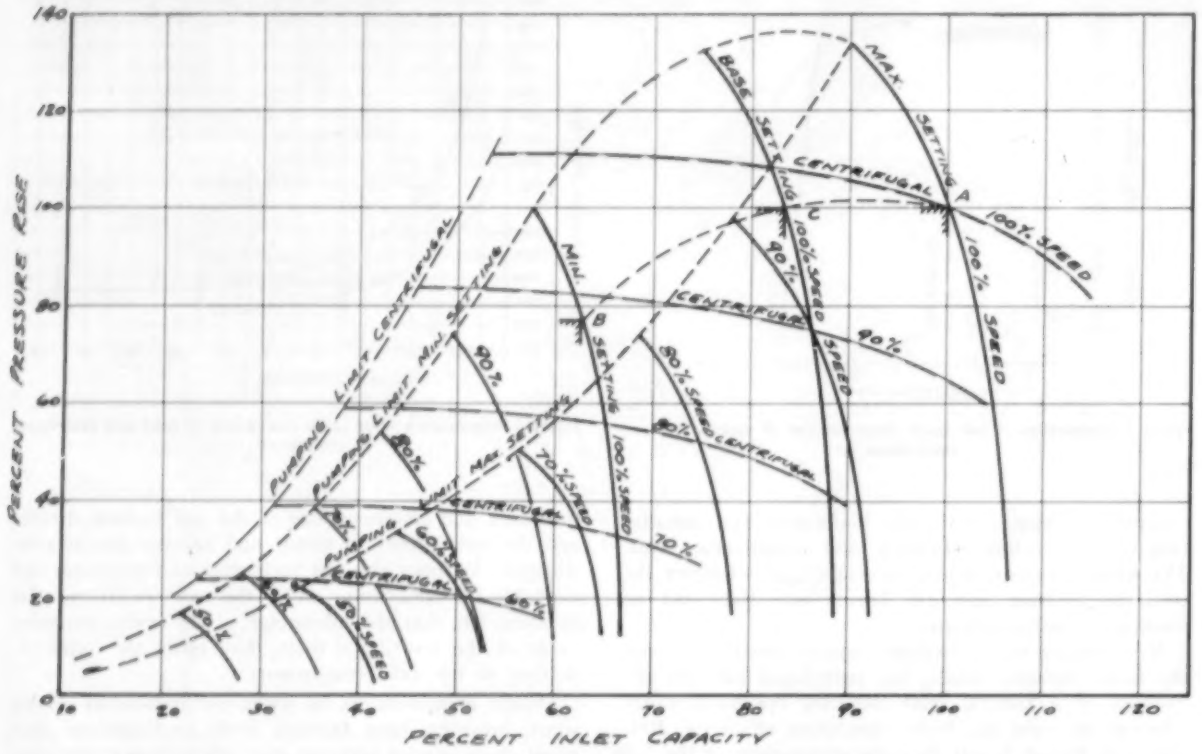

Figure 7. Pressure-Capacity characteristic comparison of an axial compressor with adjustable stator blades with a centrifugal compressor.

stator blade adjustment with a standard centrifugal compressor. This chart is plotted in percent pressure rise and percent inlet capacity.

The centrifugal characteristic curves are marked for 100 percent speed and for reduced speeds down to 60 percent with the approximate pumping limit indicated. Additional capacity range is available with a centrifugal below the pumping limit shown by the use of inlet guide vanes. Inlet guide vane performance, however, is not shown on this curve.

Superimposed on this centrifugal characteristic curve are curves for three different complete stator blade settings of a comparable axial compressor. The maximum blade angle setting of all stationary blades provides a full speed pressure-capacity curve going through point "A" at 100 percent pressure rise and 100 percent capacity. From this maximum setting with the rated point at "A", a family of reduced speed lines have been drawn to show the variable speed range available with the axial blading adjusted to this maximum setting.

The full speed base setting curve for the axial is shown going through point "C" at 100 percent pressure rise and approximately 86 percent capacity. That curve shows the pressure-capacity characteristic of the axial with the normal stator blade angle.

If the stator blade angle is changed to the minimum, the rated point for the axial compressor will travel to point "B." The rated point at this minimum setting will then be located at approximately 77 percent pressure rise and 62.5 percent capacity. With this minimum stator blade setting a second family of reduced speed curves have been drawn to show the variable speed characteristic of the machine at this minimum setting.

Since the rated point of the axial compressor can be adjusted to any point between "A" and "B," the entire range between the maximum and minimum settings is available to meet capacity fluctuations with the present design of axial compressors. For a machine having a constant speed driver, the range would be limited to the 100 percent speed lines shown. For a machine with a variable speed driver, the additional range using reduced speed below the minimum setting line is available.

As previously stated, each of the various types of compressors reviewed, has its own particular operating advantages and disadvantages. The compressors have been roughly grouped as small, medium, and large capacity machines and comparisons made between the reciprocating, the centrifugal and the axial types. Even though certain applications will favor the use of positive displacement machines other than reciprocating, the reciprocating machine probably is the most often used positive displacement machine in petroleum refining service. The present trend is toward the use of rotating dynamic-type compressors, primarily centrifugals, but as the capacity requirements increase, axials will again find a definite place for this service. ##

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Figure 2 and the various compressor definitions are taken from the Compressed Air Handbook, Second Edition, 1954, Published by McGraw-Hill Book Company, Inc.

2. Theory of Operation

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Elliott Company,
Jeannette, Pa.

CENTRIFUGAL COMPRESSORS are simple in construction and can be explained by relatively simple means. A single-stage compressor consists essentially of the following basic elements: (a) Inlet connection, (b) Impeller, (c) Diffuser, (d) Casing (or volute), (e) Shaft and bearings and (f) Shaft seal.

Gas enters the compressor through the inlet connection, which is proportioned to minimize shock or turbulence as the gas enters the impeller. The impeller imparts velocity to the gas and delivers it to the diffuser where the velocity energy is gradually converted to pressure energy. The volute completely surrounds the diffuser and serves to collect the gas, and to recover additional velocity energy. The impeller may be mounted directly on an extension of the driver shaft, or the compressor may have its own shaft and bearings. In either case there must be a shaft seal where the shaft passes through the casing, the type of seal depending upon the pressure level and the nature of the gas being handled. When the pressure level exceeds the limits of a single-stage, a multistage compressor must be used; this construction requires a return passage to take the gas leaving each diffuser and to deliver it to the inlet of each succeeding stage.

Centrifugal compressors are built to handle a wide variety of gases or mixture of gases with inlet flows ranging from 500 cfm to about 150,000 cfm per impeller inlet, and for pressure rises ranging from about one psi to several hundred psi. Of course, no one compressor can be designed to cover this range, but the design point for any individual compressor will fall within this field. They are designed taking into account the following variables which will be designated throughout this discussion in the following units:

(1) P_a = Barometric pressure, psia = 0.491 × "Hg.
(2) ΔP = Pressure rise, psi = $P_2 - P_1$
(3) P_2 = Discharge pressure, psia
(4) P_1 = Inlet pressure, psia
(5) T_1 = Inlet temperature, °F absolute = 460 + °F.
(6) M = Apparent molecular weight, a ratio = 28.95 for air = 28.95 × Sp. Gr. for gas
(7) Z = Compressibility factor = deviation factor from Boyle's and Charles' laws
(8) k = Ratio of specific heats = C_p/C_v = 1.395 for air
(9) Q_1 = Flow, cfm at inlet conditions
(10) N = Rotative speed of compressor, rpm

Of the above variables it should be noted that the barometric pressure and the pressure rise are correlated with inlet and discharge pressures, and as such are not independent variables. The independent variables which directly influence the design of a compressor are items 3 to 10 inclusive and, of these items, 6 to 8 inclusive are physical properties, associated with any given gas.

For any given set of conditions and physical properties of the gas handled, the rotating speed selected must either conform to a given driver speed or a rotative speed which will give desirable impeller proportions. These two may or may not be compatible; if not, gearing may have to be interposed between the driver and the compressor.

In centrifugal compressors, the normal head will be in the range from 2500 feet to about 75,000 feet, in feet of the fluid handled; in comparison, for centrifugal water pumps the normal head will be in the range from a few feet to about 3000 feet in feet of water. Even though the head developed by any given impeller is a function of the rpm squared, it is obvious that centrifugal compressors are inherently machines of high rotative speeds. This explains in a general way the relatively high and apparent non-standard rotative speeds of centrifugal compressors, which may vary from approximately 2000 rpm to 30,000 rpm, depending upon the head and flow for the specific application.

Since we are primarily concerned with impellers, we will first outline the various types of impellers used in centrifugal compressor work: (a) Single-inlet, (b) Double-inlet, (c) Open, (d) Semiclosed, (e) Closed, and (f) Mixed-flow.

Single-inlet impellers take the gas in an axial direction, on one side of the impeller only and discharge the gas in a radial direction.

Double-inlet impellers take the gas in an axial direction, on both sides of the impeller, and discharge the gas in a radial direction. They are, in effect, the equivalent of two single-inlet impellers placed back to back and, in general, will handle twice the flow at the same head as a single-inlet impeller of the same diameter and operating at the same rotative speed.

Open impellers are normally built with the vanes in a radial direction and have no enclosing covers on either the front or back sides.

Semiclosed impellers are usually built with the vanes in a radial direction and have an enclosing cover on the back

Theory of Operation . . .

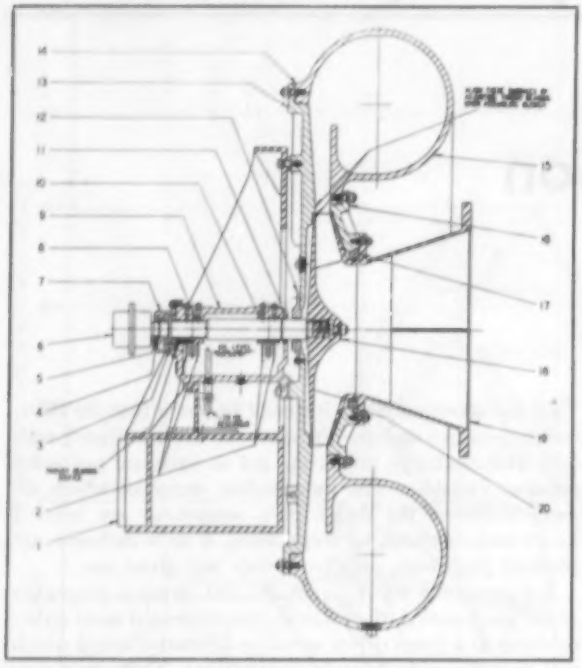

Figure 1. Single-stage compressor with closed impeller. Parts list: 1, base; 2, oil rings; 3, thrust bearing assembly; 4, oil guard—coupling end; 5, shaft; 6, coupling; 7, thrust bearing housing; 8, bearing sleeve—coupling end; 9, bearing housing; 10, bearing sleeve—impeller end; 11, oil guard—impeller end; 12, packing box; 13, backplate; 14, gasket; 15, casing; 16, adaptor; 17, seal ring—impeller; 18, impeller; 19, inlet connection; 20, impeller seal ring key.

side which extends to the periphery of the vanes.

Closed impellers are built with enclosing covers on both the front and back sides. They usually have the vanes tipped in a backward-leaning direction, although they may have radial vanes. Forward-leaning vanes are possible but are seldom used with centrifugal compressors.

The above impellers are for radial discharge of the gas but, since the gas is taken into the impeller in an axial direction, an axial flow element is sometimes combined with the radial flow element. They have been used for many years with various names applied to the axial flow element such as guide wheel, inducer, etc. The preferred term for the axial flow element is an "inducer," but the combination is a *mixed-flow impeller*.

In centrifugal compressor work, including design, application, and appraisal of operation, we are largely concerned with fluid flow and, therefore, a brief review of the problems involved is essential to properly understand this class of machinery.

The fundamental theoretical concept of fluid flow pictures an ideal frictionless fluid, in uniform laminar flow, which does not allow for non-uniformity of flow with resultant drag forces and eddy losses. All actual fluids have finite viscosities, which result in friction between the fluid and the walls of the system, and between adjacent layers of the fluid itself. This results in a velocity gradient between the fluid and the walls of the system, and between adjacent layers of the fluid itself. This non-uniform velocity in turn, directly or otherwise, results in drag forces and/or hydrodynamic losses.

To analyze the problems involved in fluid flow and to correlate experimental results for application and/or appraisal of operation of centrifugal compressors, frequent references are made to various coefficients, various heads, and various efficiencies. Because the terms for both head and efficiency may each have as many as four different meanings, it is essential that they be carefully defined. This is doubly important since any explanation, analysis, or comparison, without the use of these terms, becomes almost an impossibility!

The derivation of these various terms can be found in text books on fluid mechanics and will not be covered herein. However, with some simplifying assumptions and by use of theoretical and dimensional analysis, the following relationships can be developed. These are the basic relationships that affect the performance of centrifugal compressors and are required to predict the effect of speed changes; to predict the effect of changes in inlet conditions; and to predict the proper operating speed when the physical properties of the gas being handled are different from the physical properties used in the design.

The basic theory of operation of centrifugal compressors can be greatly simplified if the head per stage is assumed to be less than 10,000 feet so that the specific weight of the fluid passing through a compressor stage remains substantially constant. This is a legitimate assumption, as it applies in the general case where the tip velocity U_2 is ordinarily of such a value that the head per stage will be less than 10,000 feet. For high tip speeds where the head per stage may be upward of 30,000 feet, the specific weight changes appreciably and, therefore, this approach is not permissible. With this simplifying assumption, the following relationships can be developed.

Figure 1 shows a single-stage compressor with an overhung, closed-type impeller with backward-leaning vanes. Fluid enters the inlet in an axial direction, makes a right angle turn, and then flows radially out through the impeller, into the diffuser, and into the casing. Tangential velocity is imparted to the fluid by the impeller as shown in the velocity diagrams of Figure II. The impeller head in the ideal case, assuming frictionless and uniform laminar flow with a complete guidance of the fluid, is given by the general Euler equation:

$$H\ (\text{ideal}) = \frac{(V_{u2} \times U_2) - (V_{u1} \times U_1)}{g} \qquad (1)$$

In the ideal case, the angles for laying out the velocity diagram are taken from the actual vane angles of the impeller. As a result of incomplete guidance, the fluid in the rotating impeller will tend to remain stationary with respect to space and as a result, a counter-rotation pattern will be set up in the impeller space between adjacent impeller vanes. The velocity component of this counter-rotation pattern at the inlet diameter will be in the same direction as the tangential velocity of the impeller but, at the discharge, this velocity component will be opposite to the tangential component of the impeller. This effect is shown on the actual velocity diagram and gives the following general results: Angle β'_1 is greater than β_1; α'_1 is less than α_1; β'_2 is less than β_2 and α'_2 is greater than α_2. As a result, the actual velocity V'_{U2} will be less than V_{U2}, and V_{U_1} is no longer zero but becomes an actual quantity. By referring to equation (1), it will be noted that the net effect of the changes in these quantities will be a head re-

duction from the ideal case. This effect will, of course, vary depending upon the impeller proportions and, therefore, is usually estimated by the use of a coefficient based upon test and experience. The actual velocity diagram is, therefore, only to illustrate this point.

Returning to the ideal velocity diagram, if the flow to the impeller is radial, V_{U_1} is zero; hence:

$$H\ (\text{ideal}) = \frac{V_{u2} \times U_2}{g} \tag{2}$$

$$V_{u2} = U_2 - \frac{V_{r2}}{\text{Tan}\ \beta_2} \tag{3}$$

$$H\ (\text{ideal}) = \frac{U_2}{g} \times \left[U_2 - \frac{V_{r2}}{\text{Tan}\ \beta_2}\right] \tag{4}$$

For any given impeller, V_{r2} will vary directly with flow. For this same impeller, if we hold the rotative speed constant, U_2 will be constant, and consequently, H (ideal) will vary linearly with flow. For angle β_2 less than 90° (backward-leaning vanes), the quantity $V_{r2}/\text{Tan}\ \beta_2$ will increase with flow and, consequently, H (ideal) will decrease with flow. For $\beta_2 = 90°$ (radial vanes), Tan β_2 is infinite and, therefore, the quantity $V_{r2}/\text{Tan}\ \beta_2$ is zero and H (ideal) will be independent of flow. For β_2 greater than 90° (forward-leaning vanes), Tan β_2 is negative so that the quantity $V_{r2}/\text{Tan}\ \beta_2$ becomes positive and, consequently, H (ideal) will increase with flow.

If we subtract from the ideal head, the head reduction resulting from incomplete guidance, the remainder is the head imparted to the fluid by the impeller. For a compressor this may be referred to as head input. The head output or actual head will be less than the input due to hydrodynamic losses. The hydrodynamic losses are the skin friction loss due to flow of the fluid through the impeller passages and turbulent losses resulting from the impeller angles not matching the flow angles. The skin friction loss will vary approximately as the square of the flow; however, the turbulent losses will be a minimum at about design flow and will increase in both directions from that point. Hydrodynamic losses will also depend somewhat upon the impeller proportions and, consequently, are usually estimated by the use of an efficiency called the hydrodynamic efficiency, η_{hd}.

As the hydrodynamic efficiency η_{hd} and the head reduction coefficient, C_H, are difficult to segregate, they are generally combined into an overall head coefficient which is commonly called μ; therefore:

$$\mu = \eta_{hd} \times C_H = \frac{\text{Head (actual)}}{\text{Head (ideal)}} \tag{5}$$

Tests indicate that the head coefficient as defined above will be approximately 0.50 at zero flow, rise to a maximum, and then decrease. The result of this change in head coefficient is that the characteristic curves for actual head versus flow will all rise to a maximum and then decrease. This explains in a general way the shape of the characteristic curves of head versus flow shown in Figure 3.

The shape of a characteristic curve of actual head versus

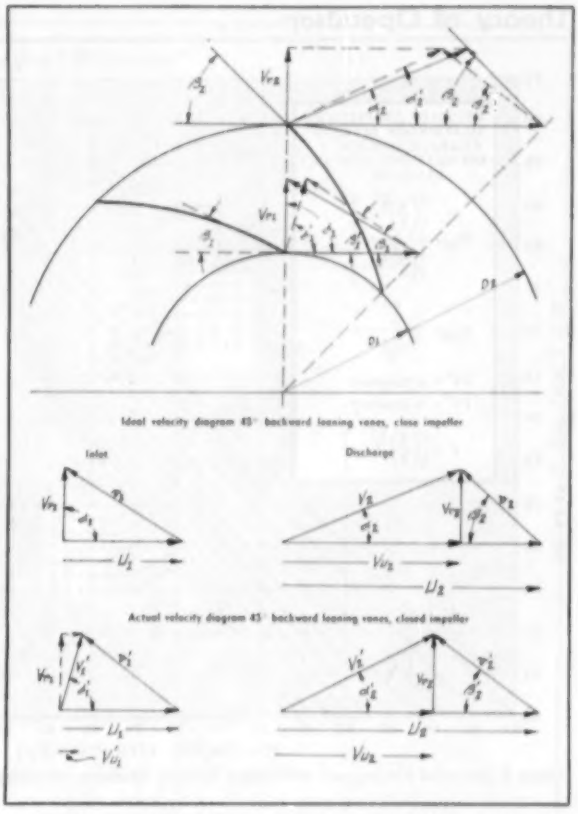
Ideal velocity diagram 45° backward leaning vanes, close impeller
Inlet
Discharge
Actual velocity diagram 45° backward leaning vanes, closed impeller

Figure 2. Tangential velocity as imparted to the fluid by the impeller.

flow shows that the negative slope of the curve (pressure decreasing with increased flow) is small for forward-leaning vanes, increases for radial vanes, and further increases for backward-leaning vanes. As the range of stable operation is limited to that portion of the curve with negative slope, it is apparent that forward-leaning vaned impellers can be applied only in isolated cases where the required stable flow range is small. For this reason, forward-leaning vanes are very seldom used.

Radial and backward-leaning vaned impellers, for single-stage compressors, can usually be made with acceptable efficiencies for a stable flow range of approximately 50 per cent. However, to maintain acceptable efficiencies for multistage units, the range of stable operation (even with backward-leaning vanes) decreases with the number of stages and may be as low as 25 per cent for an eight-stage unit. This fact is not always recognized but must be kept in mind in the application of centrifugal compressors.

To compare centrifugal compressors, or to predict per-

Centrifugal Compressors

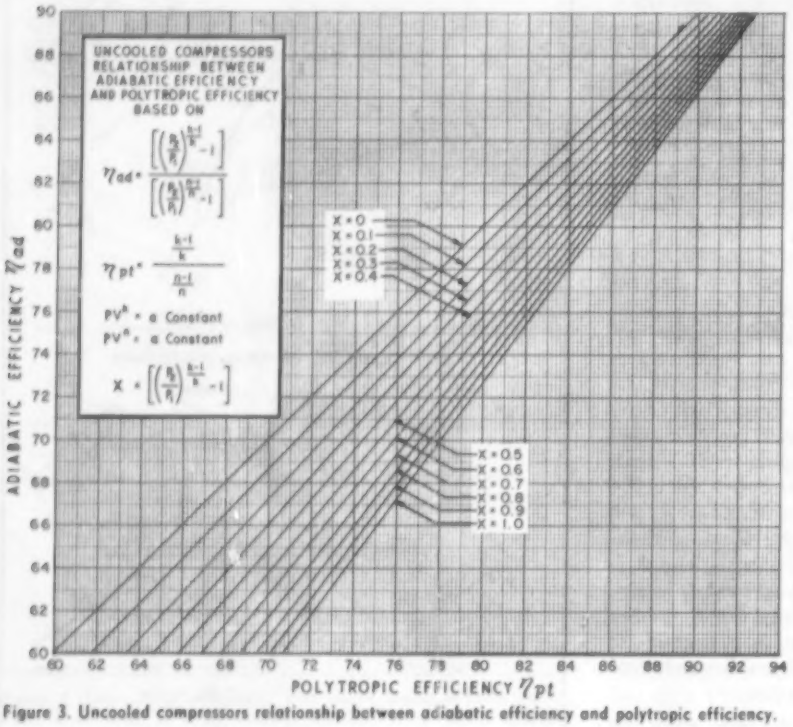

Figure 3. Uncooled compressors relationship between adiabatic efficiency and polytropic efficiency.

formance when the operating conditions vary from the design conditions, other relationships are required. These are tabulated below for ready reference.

Tabulation of basic relationships for head per stage less than 10,000 feet:

$$\frac{g \times H}{U_2^2} = f_1\left[\frac{Q_1}{60 \times U_2 \times D_2^2}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2}{60 \times \sqrt{g \times k \times \frac{1545}{M} \times T}}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2^2 \times \gamma_1}{60 \times \mu' \times g}\right] \tag{6}$$

$$\eta = f_2\left[\frac{Q_1}{60 \times U_2 \times D_2^2}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2}{60 \times \sqrt{g \times k \times \frac{1545}{M} \times T}}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2^2 \times \gamma_1}{60 \times \mu' \times g}\right] \tag{7}$$

$$\frac{g \times HP}{\gamma_1 \times \left(\frac{N}{60}\right)^3 \times D_2^5} = f_3\left[\frac{Q_1}{60 \times U_2 \times D_2^2}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2}{60 \times \sqrt{g \times k \times \frac{1545}{M} \times T}}\right] \quad ; \quad \left[\frac{\pi \times N \times D_2^2 \times \gamma_1}{60 \times \mu' \times g}\right] \tag{8}$$

where H = head, measured in ft. of the fluid handled

D_2 = impeller diameter, ft.

U_2 = impeller tip velocity, ft. per sec.

HP = horsepower

γ = specific weight of the gas, lb per ft^3 = $0.0931 \times P \times \frac{M}{T} \div Z$

μ' = absolute viscosity, pound seconds per ft^2

g = gravitational constant, 32.17 ft per sec^2

η = efficiency

Other quantities are as defined before and, with the quantities defined, we can classify these dimensionless parameters as follows:

$$\frac{g \times H}{U_2^2} = \mu = \text{Rateau head coefficient} \tag{9}$$

$$\frac{\text{Constant} \times Q_1}{U_2 \times D_2^2} = \delta = \text{Rateau volume coefficient} \tag{10}$$

$$\frac{\pi \times N \times D_2}{60 \times \sqrt{g \times k \times \frac{1545}{M} \times T}} = M_a = \text{Mach number} \tag{11}$$

$$\frac{\pi \times N \times D_2^2 \times \gamma_1}{60 \times \mu' \times g} = R_e = \text{Reynolds number} \tag{12}$$

Experience shows that, except for extreme conditions, the Mach number and the Reynolds number have very little effect on performance, hence, for the general case we have:

$$\mu = \eta_{hd} \times C_H = \frac{g \times H}{U_2^2} = f_4[\delta] \tag{13}$$

$$\eta = f_5[\delta] \tag{14}$$

$$\frac{g \times HP}{\gamma_1 \times \left(\frac{N}{60}\right)^3 \times D_2^5} = f_6[\delta] \tag{15}$$

Since $\delta = \frac{\text{Constant} \times Q_1}{U_2 \times D_2^2}$ it follows that for a given compressor where D_2 is fixed, to maintain δ at a constant value the flow Q_1 must vary directly as U_2 and consequently directly as N.

Equation (13) therefore means that for δ = a constant value, μ will also have a constant value, and consequently H must vary directly as U_2^2 or as N^2.

Equation (14) means that for δ = a constant value, η will also have a constant value neglecting the effects of the Mach and Reynolds numbers; experience shows that this is a fact.

Equation (15) means that for δ = a constant value, HP

Tabulation of Heads and Efficiencies

$$\text{Adiabatic Work} = H_{ad} = \frac{k}{k-1} \times 1545 \times \left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right] \times \frac{T_1}{M} \times Z, \text{ in ft. lb./lb.} \quad (16)$$

$$\text{Hydrodynamic Work} = H_{hd} = \frac{n}{n-1} \times 1545 \times \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right] \times \frac{T_1}{M} \times Z, \text{ in ft. lb./lb.} \quad (17)$$

$$\text{Polytropic Work} = H_{pt} = \frac{k}{k-1} \times 1545 \times \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right] \times \frac{T_1}{M} \times Z, \text{ in ft. lb./lb.} \quad (18)$$

$$\text{Adiabatic Efficiency} = \eta_{ad} = \frac{\text{Adiabatic Work}}{\text{Polytropic Work}} = \frac{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right]}{\left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]} \quad (19)$$

$$\text{Polytropic efficiency} = \eta_{pt} = \frac{\text{Hydrodynamic Work}}{\text{Polytropic Work}} = \frac{\frac{n}{n-1}}{\frac{k}{k-1}} = \frac{n(k-1)}{k(n-1)} = \frac{\frac{k-1}{k}}{\frac{n-1}{n}} \quad (20)$$

$$\text{Hydrodynamic efficiency} = \eta_{hd} = \frac{\text{Adiabatic Work}}{\text{Hydrodynamic Work}} = \frac{\frac{k}{k-1}}{\frac{n}{n-1}} \times \frac{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right]}{\left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]} = \frac{\eta_{ad}}{\eta_{pt}} \quad (21)$$

will vary directly as the product of $\gamma_1 \times N^3$. Therefore, if we maintain the inlet conditions constant, HP will vary directly as N^3.

As stated above, the terms for both head and efficiency have several different meanings; hence, we will tabulate below the definitions of the various heads and efficiencies used in uncooled centrifugal compressor work.

Tabulations of heads and efficiencies are shown at the top of the page.

Where k is from the expression PV^k = a constant; k is, therefore, the isentropic exponent and for perfect gases $= C_p/C_v$; n is from the expression PV^n = a constant; n is, therefore, the polytropic exponent; therefore:

$$\text{Polytropic Head} = \frac{\text{Adiabatic Head}}{\eta_{ad}} = \frac{\text{Hydrodynamic Head}}{\eta_{pt}}$$

$$\text{Since } \eta_{ad} = \frac{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right]}{\left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]} \quad \text{and} \quad \frac{n-1}{n} = \frac{\frac{k-1}{k}}{\eta_{pt}}$$

$$\text{If we let } X = \left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right] \quad \text{we then have} \quad (22)$$

$$\eta_{ad} = \frac{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right]}{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}/\eta_{pt}} - 1 \right]} = \frac{X}{[1+X]^{1/\eta_{pt}} - 1} \quad (23)$$

The above relationship between η_{ad} and η_{pt} is shown plotted in Figure 3 for various values of X.

$$\text{Since } \frac{T_2}{T_1} = \left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} \quad (24)$$

Substituting Equation (24) in Equation (19) we have

$$\eta_{ad} = \frac{\left[\left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} - 1 \right]}{\frac{T_2}{T_1} - 1} = \frac{T_1 \times X}{T_2 - T_1}, \text{ which by definition is the}$$

temperature rise efficiency, η_t; therefore:

$$\eta_{ad} = \eta_t \quad (25)$$

For uncooled compressors it can be shown that the shaft work and the change in enthalpy are equal; moreover, if we neglect the external seal leakage loss, the disc friction loss, and the bearing friction loss, both the shaft work and the change in enthalpy are equal to the head imparted to the fluid by the impeller. This is an important relationship as it permits the determination of the impeller tangential

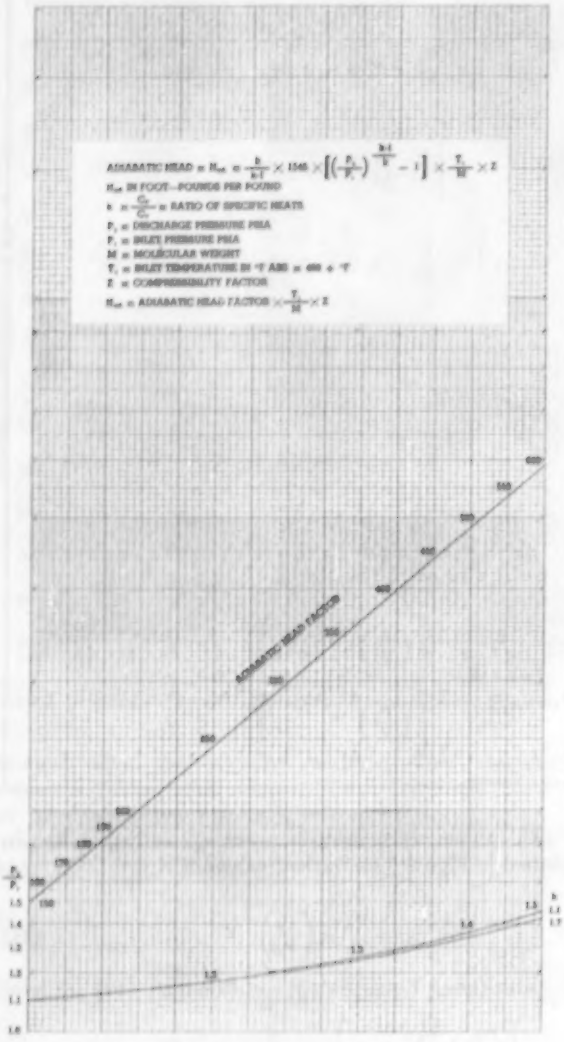
ADIABATIC HEAD = $H_{ad} = \frac{k}{k-1} \times 1545 \times \left[\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} - 1\right] \times \frac{T_1}{M} \times Z$
H_{ad} IN FOOT—POUNDS PER POUND
$k = \frac{C_p}{C_v}$ = RATIO OF SPECIFIC HEATS
P_2 = DISCHARGE PRESSURE PSIA
P_1 = INLET PRESSURE PSIA
M = MOLECULAR WEIGHT
T_1 = INLET TEMPERATURE IN °F ABS = 460 + °F
Z = COMPRESSIBILITY FACTOR
H_{ad} = ADIABATIC HEAD FACTOR $\times \frac{T_1}{M} \times Z$
ADIABATIC HEAD FACTOR
$\frac{P_2}{P_1}$
k

Figure 4, Section 1. Adiabatic head chart.

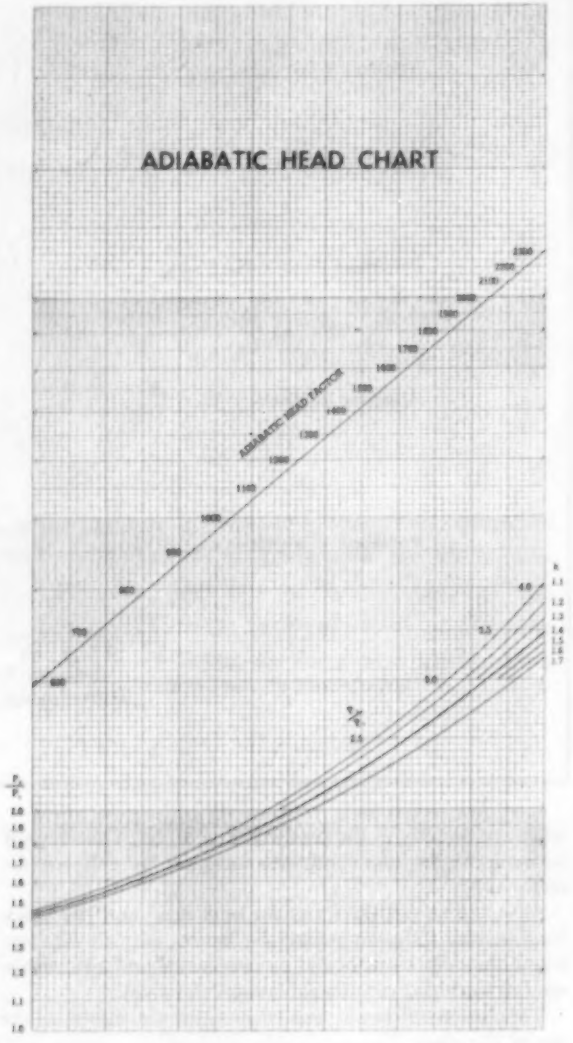

Figure 4, Section 2. Adiabatic head chart.

velocity from thermodynamic considerations. In other words, if the change in enthalpy is calculated in foot, pounds per pound, Equations (1) and (5) can be used to determine the tangential velocity of the impeller.

For uncooled compressors the actual head is calculated from the pressures required and is calculated assuming adiabatic compression. For convenience in determining adiabatic head, Figure 4 is included herewith.

In order to predict the effect of changes of speed on head, flow, and horsepower, and the effect of changed inlet conditions or of changed physical properties, the following relationships are summarized below:

$$gH = U_2^2 \times f_s\,[\delta] \qquad (13)$$

$$\eta = f_\eta\,[\delta] \qquad (14)$$

$$HP = \gamma_1 \times N^3 \times D_2^5 \times f_p\,[\delta] \qquad (15)$$

Based on the above relationships, the effect of changes in speed on head, flow, and horsepower are shown on Figure 6, where the inlet conditions and molecular weight have been assumed to remain unchanged from design conditions.

The effect of changes in inlet conditions or of changes in the molecular weight of the gas handled is somewhat more difficult to predict, but it can be done if we remember that the adiabatic head measured in feet of the gas handled, for a given compressor, operating at a given rpm, and at a given flow will be substantially constant, irrespective of the inlet conditions or of the molecular weight of the gas handled provided that "k" remains substantially constant.

It follows, therfore, that for everything else remaining the same, the pressure ratio will increase for increasing values of M, and will decrease for increasing values of T_1. Therefore, to maintain the design pressure ratio where the actual gas has a molecular weight less than design, everything else remaining the same, means that the rpm would have to be increased and vice versa. Overspeed

limitations, however, generally prevent overspeeding; hence, in the general case, the design pressure ratio cannot be attained if the actual gas has a molecular weight less than design. On the other hand, although the design pressure ratio can be theoretically obtained if the actual molecular weight is greater than design, the flow and/or the inlet pressure may have to be restricted to stay within power limitations of the driver, as indicated by Equation (15), if the molecular weight change is appreciable.

The adiabatic head factor, Figure 4, is a convenient tool for predicting operating conditions when the actual inlet conditions or the molecular weight are different from design. To do this, proceed as follows:

1. Read adiabatic head factor from Figure 4 for design conditions.
2. Correct H_{ad} factor as follows:

$$H_{ad}\text{ factor (actual)} = H_{ad}\text{ factor (design)} \times \frac{M\text{ (actual)}}{M\text{ (design)}} \times \frac{T_1\text{ (design)}}{T_1\text{ (actual)}} \quad (26)$$

$$N\text{ (actual)} = N\text{ (design)} \times \sqrt{\frac{H_{ad}\text{ factor (design)}}{H_{ad}\text{ factor (actual)}}} \quad (27)$$

In the above, it is assumed that the value of "k" has not changed appreciably. If the value of "k" under actual conditions is widely different from design, the approximation given above is no longer valid, especially for multistage units, unless the over-all pressure ratio is small as in the case of compressors handling the lighter gases, or for single-stage units.

To illustrate how this can be handled assume that there is a turbine driven compressor designed for the following:

$P_1 = 15$ psia	$M = 16$
$P_2 = 45$ psia	$k = 1.3$
$P_2/P_1 = 3.0$	$N = 4000$ rpm
$T_1 = 100$ F = 560 Fabs.	

In the actual case we have the following:

$T_1 = 50$ F = 510 F abs.
$M = 20$
$k = 1.3$

The problem is to predict the proper rotative speed for the actual conditions so that the compressor will develop the same pressure ratio as design. From Figure 4 the adiabatic head factor for design conditions is 1940.

From Equation (26) this is corrected as follows:

$$H_{ad}\text{ factor (actual)} = 1940 \times \frac{20}{16} \times \frac{560}{510} = 2665$$

From Equation (27) we have:

$$N\text{ (actual)} = 4000 \times \sqrt{\frac{1940}{2665}} = 3410\text{ RPM} = 85.4\%\text{ of design rpm.}$$

Since the HP for δ = a constant will vary as the product of $\gamma_1 \times N^3$, the required hp at the actual rpm will be:

$$\gamma_1\text{ (actual)} = \gamma_1\text{ (design)} \times \frac{M\text{ (actual)}}{M\text{ (design)}} \times \frac{T_1\text{ (design)}}{T_1\text{ (actual)}} \times \frac{P_1\text{ (actual)}}{P_1\text{ (design)}} \quad (30)$$

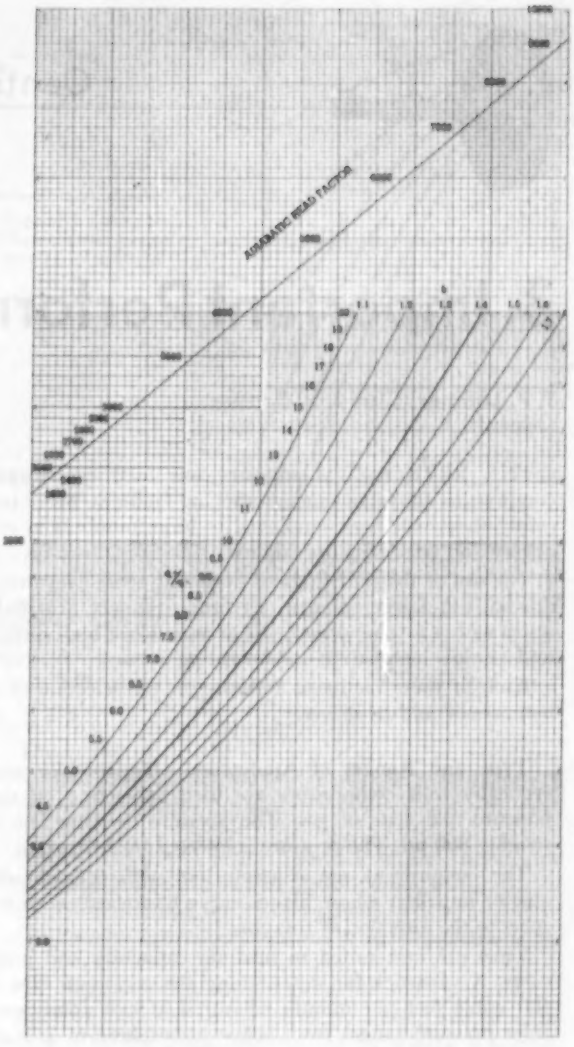

Figure 4, Section 3. Adiabatic head chart.

$$\gamma_1\text{ (actual)} = \gamma_1\text{ (design)} \times \frac{20}{16} \times \frac{560}{510} \times \frac{15}{15} = 137\%\text{ of design }\gamma_1$$

$$HP\text{ (actual)} = 137 \times \left(\frac{3410}{4000}\right)^3 = 85\%\text{ of design HP}$$

Since this is a turbine drive and since the operating hp is 85 percent of design and the operating rpm is 85.4 percent of design, the turbine will carry the load at the reduced speed. However this point should be checked in each case where the actual conditions differ from the design. It should be noted that the flow for the new speed will be 85.4 percent of the normal design flow. ##

Centrifugal Compressors

3. Important Performance Characteristics

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Olean, N. Y.

THE PETROLEUM industry has used centrifugal compressors for some time in cracking facilities. More recently they have been employed in large numbers in recovery and reforming operations.

The use of the centrifugal is becoming more prevalent, due to: (1) Larger plants, (2) fitting refinery heat balances with a turbine driver, (3) acceptance of high speeds and (4) low installation and operating costs.

Each of these factors is reflected in the selection of a compressor and its driver.

Type and Ranges of Application—Horizontally and vertically split compressors are used depending on the pressure and type of gas. The pressure dividing line is roughly 800 psi. The pressure is lowered for hydrogen.

The compressors are characterized with constant diameter impellers whose blades curve backwards with respect to the direction of rotation.

They are best suited to medium capacities and pressures. A yardstick for determining the minimum flow is 400 cubic feet per minute measured at exit conditions. Inlet pressure ranges from below atmosphere to as high as 600 psig. Discharge pressures range up to 1000 psig and non-refining applications may require considerably higher pressures.

Pressure-Volume Characteristics—There is one characteristic peculiar to a gas compressor as opposed to a pump. This is the phenomena of surge wherein the compressor does not meet the pressure of the system into which it is discharging. This causes a cycle of flow reversals as the compressor alternately tries to deliver gas and the system returns it. It is due to the compressibility of a gas. Surge may be caused by a system disturbance or insufficient flow.

The point of surge due to flow is a minimum with a single impeller or, alternately, the range of stable operation is a maximum. This range, which is defined as a percent of rated inlet volume at constant discharge pressure, decreases approximately five percentage points with the addition of each impeller. Hence, if a four impeller air compressor has a 50 percent stable operating range, the addition of two impellers will decrease the range to 40 percent. The molecular weight of the gas will also influence this figure. High molecular weights decrease it while lighter gases extend the stable operating range.

The "stonewall" or sonic barrier is generally reached at the eye of the first impeller. A further increase in flow cannot occur past this point.

The efficiency of the compressor normally peaks to the left of the rating point and drops on both sides of the peak toward surge or the stonewall.

The characteristic curve is a summation of the decision made on placing the rating point with respect to surge, efficiency and the stonewall. This curve is shown in Figure 1 with the rating point placed for optimum stability and efficiency. Additional capacity at a reduced pressure is also indicated.

Operation "back on the curve" will increase the efficiency at the cost of a narrower stability range whereas moving the rating point out on the curve will lower the efficiency and increase the stability. Every selection is therefore a suitable compromise of these factors.

Parallel and Series Operation—Most refinery installations operate at high load factors and the range of operation of a single compressor is adequate. However on new processes such as reforming, parallel operating units have been installed as an insurance measure.

The long term trend is toward single compressors with a spare rotor, due to the confidence gained with long periods of successful operation. Single units for catalytic cracking and gas recovery units are examples of this trend.

Performance Calculations—Selection of an uncooled compressor requires the following data:

1. Gas Characteristics
2. Inlet conditions and discharge pressure
3. Type of driver
4. Driver operating conditions
5. Any special consideration or limitations due to process, surrounding atmosphere or parallel units.

The majority of refinery uses involve gases that do not follow ideal gas laws. Therefore, ideal gas behavior is the exception rather than the rule. All performance calculations are based on this premise.

List of Typical Data

	Symbol
1. Gas	
2. Mmscfd at.....psia.....°F.	
3. Inlet Volume, cfm	Q_s
4. Suction Pressure, psia	P_s
5. Suction Temperature, °R	T_s

		Symbol
6.	Discharge Pressure, psia	P_d
7.	Barometric Pressure, psia	
8.	Molecular Weight	M
9.	Average Compressibility	Z
10.	Gas Constant	R
11.	Isentropic Exponent	α

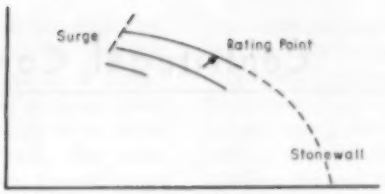

Figure 1 (above). Characteristic curve showing efficiency of compressor.

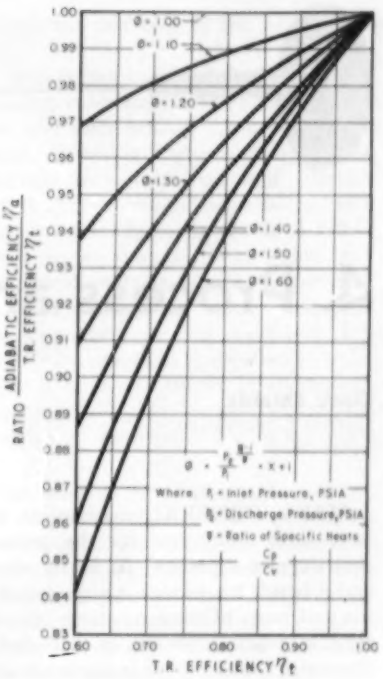

Figure 2 (right). Convenient curve for conversion of a polytropic to adiabatic head.

It will be noted that the user specifies the molecular weight as well as the isentropic exponent of compression. The latter is frequently different from the ratio of specific heats and is required for an accurate determination of the discharge temperature.

Secondly, it is desirable to specify the average compressibility factor. Determination of the number of stages, operating speed and driver selection are dependent on this figure.

		Symbol	Formulae
12.	Specific Volume, of 3/lb.	v_s	$\frac{ZRT}{144P}$
13.	Mass rate of flow, lb.	W	Q_s / v_s
14.	Hydraplic Efficiency, %	n_h	Mfg. Data
15.	Exponent of Compression, n	m	$\frac{\alpha-1}{n_h} = \frac{n-1}{n}$
16.	Compression Ratio	r	P_d/P_s
17.	Head, ft. lb./lb.	H	$\frac{ZRT\,(r^m-1)}{m}$
18.	Gas horsepower,	GHP	$\frac{HW}{33{,}000 \times n_h}$
19.	Total horsepower, hp	BHP	1.01 GHP
20.	Discharge Temperature, °F.	T_d	$T_s \times r^m$
21.	Pressure co-efficient	μ	Assume 0.55
22.	Speed, rpm	N	$\frac{1300}{D^*}\sqrt{\frac{H}{\text{Stages} \times \mu}}$
23.	Inlet Rating	Q_s/N	
24.	Discharge Rating	Q_d/N	

* Impeller Diameter, inches.

The significant items are the head, volume, horsepower and speed.

Head—The polytropic head is used because it allows the use of hydraulic efficiency. This efficiency gives a true picture of compressor losses that is independent of compression ratio.

Some manufacturers use adiabatic head. A convenient curve for the conversion of polytropic to adiabatic head is given in Figure 2.

The polytropic head is related to the hydraulic design of the compressor. This relation is:

$$\text{Head/Impeller} = \frac{(\text{A constant}) \times (\text{Tip Speed})^2}{\text{Gravitational Constant}}$$

This constant is known as the pressure coefficient and is a function of the compressor design. An easy rule of thumb value is 0.55.

Tip speeds are visible manifestations of impellers stresses. Reasonable designs use values of 770 feet per second or less. Substitution of these values in the head equation gives a figure of 10,000 foot pounds per pound.

The total head in the calculation may be divided by this figure and the next largest whole number represents the number of impellers.

Volume—The inlet capacity determines the compressor diameter or size. For a given design it is related to speed. A convenient parameter known as Q/N (i.e. Volume/Speed) is used to size the compressor.

This parameter is also checked at discharge conditions and must fall within the range of the manufacturers rating conditions.

Speed—The speed is determined from the frame size, and head per impeller. It may be varied due to:

(1) Need or desire for a lower speed,
(2) Parallel operation requiring a steeper characteristic, or
(3) High molecular weight gases and sonic problems.

Each of these variations is met by adding one or more impellers to the frame selected, or by adding a second case.

Horsepower—Gas horsepower is given in the formula:

$$GHP = \frac{\text{Head} \times \text{Mass rate of flow}}{33{,}000 \times \text{efficiency}}$$

Friction horsepower from bearings and seals must be added to this figure.

The hydraulic efficiency is a measure of the "losses" inside the compressor such as shock, turbulence, disc friction, etc. It is exclusive of friction horsepower resulting from bearing and seal losses. The friction horsepower which is 1-2 percent of the gas horsepower must be added.

The losses decrease as the size of the compressor increases since the relation of area and volume is less. The losses increase as stages are added.

Conclusion—The foregoing items will enable an engineer to select or better evaluate single compressors, involving such applications as catalytic cracking, gas recovery and catalytic reforming. Two case offerings with a single drive involve only a head correction for a different frame size. ##

4. Process and Mechanical Design

Clark Shields,
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Syracuse, N. Y.

MANY GENERAL mechanical design specifications have been established for the present day commercial centrifugal compressor. As better materials are obtained and a better knowledge is acquired of the function of the integral parts of these machines, the limits of good commercial practice are being extended. By virtue of this increased knowledge, it is expected and there is obtained longer trouble-free service life than was experienced in the past.

The service requirements for centrifugal compressors have also become more challenging as new processes are developed and gases which chemically attack ordinary materials must be compressed. Fortunately, as the process needs have changed, the metallurgist has supplied higher strength and more corrosive resistant materials. This makes it possible to handle all but a very few gases and vapors. Even extremely corrosive fluids can be handled if limited service life can be tolerated.

The centrifugal compressor industry has established many standards which define the present day commercial machine.

Compressor shells or casings are usually designed to withstand internal hydrostatic test pressures of one and one-half times the working pressure. Most manufacturers also test the casing at full working pressure with gas under water to observe any leaks by bubble formation. Or, a tracer gas can be used and minute leaks are detected by means of a halide lamp or an electronic leak detector. This latter method is extremely sensitive.

Compressor rotors will differ depending upon the design practices of the various manufacturers and compressor requirements. The individual impellers can be manufactured by several different methods. They can be built up by welding or by riveting the blades to the hubs and covers. Or they can be cast or completely machined from a solid forging. The latter impellers are of the open design.

The tip speed at which impellers are usually operated will range from about 800 feet per second as a maximum for riveted construction up to 1300 feet per second for open impellers machined from a solid forging. These speeds are not absolute limits by any means, and will be exceeded in commercial practice by centrifugal compressors of the future.

For many applications of centrifugal compressors low tip speeds are desired, because a low speed impeller with backward curved blades will produce a wide stable operating range. The high tip speed, radial vane design, on the other hand, will limit the volume flow range over which the compressor can operate without pumping or "surging." As the tip speed of the impeller increases, the centrifugal compressor characteristic approaches that of the axial compressor; a very steep curve with small stable volume range.

To prove the adequacy of the impeller, it is the general practice of the manufacturer to overspeed test the individual impellers and then the complete rotor assemblies. The complete rotors are usually tested at speeds of 110 percent of the maximum allowable continuous operating speed specified for the compressor. During the manufacture, the individual impellers are overspeeded to at least 115 percent of the maximum continuous speed specified for the compressor.

In discussing speeds up to this point, no mention has been made of revolutions per minute. This must follow directly from the tip speed limitations and the volume capacity desired in the centrifugal compressor. The tip speed will determine the pressure rise per stage which is theoretically attainable, but a limit on rpm will determine to a large extent the efficiency and actual pressure rise which is attainable.

For example, the limit on rpm has been established at approximately 10,000 rmp for the past several years. This means that the individual impellers cannot be designed to give satisfactory efficiency for flows less than about 500 actual cfm. Below this flow with impellers limited to 10,000 rpm and large enough to have a reasonable tip speed (pressure rise) the gas flow passages become so narrow that aerodynamic losses become great, and the efficiency becomes quite unattractive. To overcome this, the future small volume compressors must be smaller in diameter and must be operated at higher revolutions per minute.

These higher speed compressors (15,000 to 20,000 rpm) do not present any real mechanical problems for the designer. Bearings and shaft seals have been under study by most manufacturers for some time and higher rotating speeds present no insurmountable problem.

Normal surface running speed for shaft journal bearings is about 140 feet per second for the present day

centrifugal compressors. However, journal bearings have been run at twice this speed with no difficulties. One fear that has entered the minds of the operators of higher rotating speed machines is the danger of bearing instability. This is a phenomenon which has recently occurred on some few compressors and their drivers. The instability results primarily when lightly loaded journal bearings are operated at high rotating speeds. The exact nature of the instabilities that result and the methods employed in design to circumvent instability troubles are too involved for this discussion, but most manufacturers of this type of machinery know how to avoid these difficulties. Unfortunately, many vibration troubles have been labeled as bearing instability and it has been a difficult task to remove this stigma even though in most cases it has been proven that the vibration came from other causes.

The shaft seals for centrifugal compressors are designed to fit the service requirements. In applications where a slight amount of gas leakage from the machine can be tolerated, a simple shaft labyrinth can be employed. This type of seal is cheap and is easy to maintain. Preventing the leakage of gas to the atmosphere can be accomplished by using a sealing gas, or by employing a seal pressurized with oil or some other fluid. Each manufacturer of centrifugal compressors can supply a variety of seals and sealing systems to meet the intended service satisfactorily.

In general, centrifugal compressor mechanical design is aimed at creating rotating elements of adequate strength to withstand centrifugal stresses and bearings of a suitable nature which will support the rotating shaft assembly. The casing must be the pressure vessel and furnish support for the journal and thrust bearings. All of this, of course, must be handled in such a way as to provide properly designed inner stage passages. The bearing span and shaft size must be such as to place the natural frequency of the shaft assembly outside the speed range needed to meet the customer's requirements. The mechanical design problems are well understood and can be solved in a straightforward manner.

In this brief discussion few mechanical design limits have been stated, since each manufacturer of centrifugal compressors will have different limiting values which best fit his basic design of the machine. However, it is safe to say that in almost any category, the present day commercial limits will be exceeded in compressors of the near future. The process requirements are demanding new types of machines and the centrifugal compressor is being extended into these new fields as the requirements develop.

Limits of pressure level, types of gases being compressed, volume flows being handled, sealing systems being employed—all of these are constantly changing as process demands require them to change.

Lubrication Systems

There are two general classifications of lubrication systems in a centrifugal compressor: (1) Lubrication of the bearings, which include the main journal bearings and the thrust bearing, must be dealt with in all compressors. (2) Lubrication must also be provided for seals. Where the seals require lubrication, they probably represent the most extreme problems of the whole compressor installation.

Journal bearings and thrust bearings have been used by industry on rotating machines for so long that the lubricating problems and their general requirements are very well established. Even at high rotating speeds, modern journal bearings are nearly fool-proof. Modern high speed bearings, in general, should have oil supplied to them at temperatures probably not in excess of 120 F. and in sufficient quantity so that the heat which they generate may be removed without an oil temperature rise of more than 40 F. There are many designs of bearings which will alter these general conditions, but in general the above limits represent a satisfactory relationship. The bearing is relatively simple in its modern form and the quantity of oil that should be supplied from the lube system is only that necessary for adequate heat removal.

As long as the compressor has no other contact surfaces, and if labyrinths or gas sealing devices are used and no other lubrication is required for seals, the lubrication system can be relatively simple. Many customers now prefer an external main oil pump and an auxiliary oil pump. One is a motor driven unit and the other is usually a steam turbine driven unit. These are operated through adequate pressure controls so that if the main oil pump fails to deliver oil pressure, the auxiliary will start up. Each of these pumps is good for continuous duty and should be able to carry all requirements of the compressor.

There are some users and some manufacturers who prefer that the main oil pump be an integrally driven unit from the main compressor shaft. This has its advantages, but also some disadvantages. Drive gear mechanisms are required. With this arrangement, external oil piping is simplified and in a great many instances the floor space is reduced. This space saving may be important for the customer.

The general trend, however, is toward replacing the internal oil pump, especially if the unit is to be operated continuously or under circumstances where it would be expensive or undesirable to take the compressor out of operation. Service failure of a shaft driven pump may require such an emergency shut-down.

As far as coolers and filters are concerned, it is generally felt that twin coolers and filters should be employed with a suitable switching arrangement. This allows one of these to be cleaned while the other unit is in operation. The only real requirement for these coolers should be that they have removable tube bundles and that they be adequate for the heat rejection service expected of them. Small tubes closely nested are the most efficient from a heat transfer standpoint. The optimum would be ⅛-inch tubes, closely nested together. However, this is not generally practical from the standpoint of clogging from the water side, with a great many of the cooling water sources that are used today.

Therefore, some compromise must be accepted and the oil cooler manufacturers have a variety to offer. It is a general recommendation that nominal ⅝-inch tubes be used to meet the general requirements of minimum floor space, minimum cost, and ease of maintenance, with good reliability. Some users of centrifugal equipment have standardized on ¾-inch prime surface

tubes for their oil coolers. There may be special reasons for this and if there are, they should be adhered to. The equipment is available, but it is more expensive and usually consumes more floor space.

Filters in the oiling system are a problem in themselves. It is very difficult to lay down specific recommendations on a general basis as to what style and type of oil filters should be used. Every job has its own problems. Filters are so vitally important that they should be in the system in such quantity that they can be cleaned, re-charged, or whatever is necessary to reactivate them, while the plant is in operation.

The filter problem becomes more acute if the gas handled will react in any manner with the oil when there is any possibility of the oil and gas coming in contact.

The above discussion tends to recommend twin coolers, twin filters, and twin pumps. There are many applications where sparing of auxiliary equipment is not warranted. The requirements should be established for the particular installation by balancing the cost of an emergency shutdowns and the normal frequency of scheduled shutdowns against the cost of the spare auxiliary equipment.

If the compressor is equipped with seals, requiring oil for heat removal or requiring oil for pressure film operation, the auxiliary system and the lube system can become more complicated.

Probably the simplest form is where the requirements of the pressure portion of the seals are sufficiently low that normal pressure lubrication oil can be used. Under those conditions, all that is required is an increase in the size of oil pumps, filters and coolers.

If, however, the seals require higher pressure levels than the journal bearings, then the seal oil problem becomes a matter of choice, either to have completely separate lube and seal oil systems or to integrate them. If it is at all possible, it is more economical from both the cost and space standpoint to use the combined system. There are fewer items of equipment to install, and fewer pumps to keep running.

If the integrated system can be used, the general method would be to supply oil at lubricating oil pressure level for the journal bearings and thrust bearings, and to do all the necessary cooling and filtering at this level. Then from the low pressure system, high-pressure oil for the seals only can be supplied by special high-pressure booster pumps.

If completely separate seal oil and lube oil systems are required, then the major items such as coolers, filters, reservoirs and pumps must all be furnished for both the seal oil and the lube oil systems. The auxiliary items for the high pressure seal oil system (above 250 pounds) become costly and cumbersome.

If the gas handled by the compressor causes contamination, chemical reaction or any other deterioration of the oil, sealing systems have been developed which are of such a nature that they completely isolate the compressor gas stream from the atmosphere and the lube oil. The quantity of oil going toward the gas stream is relatively minute. Under some conditions, this contaminated oil might well be thrown away. It is probably less expensive to do this than to set up a purification system with elaborate filters which may be chemical as well as mechanical and to maintain that system as well as operate it. Oil loss rates for seals currently on the market are between one and eight quarts per day per seal.

The lubrication systems of some compressors and drivers may be combined under satisfactory operating conditions. If the lubrication oil of the compressor is not in contact or contaminated with the gas stream in any way, it is completely acceptable to combine them. This is particularly true when the driver happens to be a motor and gear set, and there is no possibility of water contamination of the oil from the steam turbine source.

However, there are many combined steam turbine and compressor lubrication systems in very satisfactory operation today. These are mainly on air compressors, but the system can be used when gases are compressed if isolating seals are used.

Requirements for Foundations

Foundations for centrifugal compressors are relatively

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simple. However, even though they may be simple, they are critical, and quite often not enough attention is given to the problem. The first requirement for the foundation for a centrifugal compressor and its driver is that it keep the equipment in perfect alignment. The second and probably equally important function is to carry the load of the unit and distribute it properly onto the floor structure.

There are two general classifications of bases: (1) Reinforced concrete with steel sole plates and (2) cast or fabricated iron or structural steel.

Concrete foundations are suggested first because in general they are the least expensive and at the same time the most satisfactory. They also tend to eliminate vibration problems such as might be caused by resonant or harmonic frequencies of the unit. Steel sole plates adequately anchored in the concrete serve as finished surfaces for alignment of the equipment. Adequate reinforcing steel, at both the top and bottom of the concrete slab, should be used.

The concrete slab should be in the order of 18 inches thick at a minimum, and will seldom be greater than 30 inches thick. It is a simple matter to provide for variations in height between compressor and driver when this concrete foundation is being poured.

Steel foundations can be useful where reduction of weight is a prime consideration, however they are costly and require quite extensive engineering design. It is a simple matter to design them with adequate strength to carry the loads, but vibration studies must be made to make sure that the steel base is not in resonance with any basic frequency of the compressor or driver.

There has been some feeling that when a continuous steel base was purchased under compressor and driver, the unit would be completely assembled and shipped as a unit from the manufacturer. This is not so in most cases because the compressor and the driver are such heavy pieces of equipment that they cannot safely be shipped in that manner. Therefore, the assembly problem remains in the field just as though no steel base was furnished.

As a third factor, many installations have been visited where steel bases have been supplied and the writer has observed that under the steel base is a simple concrete slab carrying the steel base. This concrete slab is raised several inches above the floor line. Since this slab had to be poured, it was necessary to establish dimensions for the depth of the steel base, and location of hold-down bolts between the steel base and the concrete slab. This was almost as much work and expense as using concrete and sole plates for direct mounting of the units. The cost of the structural steel here was an extra item.

If the unit is to be mezzanine mounted on a steel framework with steel floor beams, then the steel base can be very readily justified, as part of the steel work.

Bases of cast iron are not too common today. The cost of the pattern equipment under the present economic atmosphere tends to make the welded steel more acceptable.

Accessibility for Maintenance

The ideal, of course, for accessibility is engine room space which will permit mounting of the compressor and driver at floor level with gas and steam lines coming up through the floor. All lubrication equipment for both turbine and compressor would be located away from the unit so that there would be a clear six-foot aisle all around the unit. In this type of arrangement, an overhead crane or a mono-rail could easily be made available to lift the upper half of the compressor casing as well as the upper half of the drive casing.

However, in many cases, this ideal is either impossible or not practical because of the cost of the space involved. There are many satisfactory substitutes that can and are being effectively used today. Certainly, the equipment should have one clear access aisle with the lube systems and gas and steam piping on the other side. It should be noted that a centrifugal compressor requires only a minimum of access room, the reason being that there are so few parts that require inspection under normal conditions. Further, these parts are generally so small that they can be handled without the use of auxiliary lifting equipment. Inspection normally would consist of removing the journal and thrust bearing parts of the compressor. In almost all designs available, these are externally accessible through either their own covers or specially designed inspection covers on the compressor housing. The basic minimum space requirement therefore, becomes sufficient room for one man to work, if no more can be provided. Most jobs will be one man operations, such as lifting the bearing cap and checking the bearing liner, or inspecting the thrust bearing shoes.

Almost every installation, with reasonable care and planning, can provide access to the centrifugal machine and its driver from each end and on one side. This is quite satisfactory and the space need not be excessively large. The end clearance should be enough to allow a man to work comfortably except in the case of certain specialized equipment which may require movement of an internal casing axially out of the end of the machine. Under these conditions, axial clearance space must be maintained.

Other items requiring maintenance are oil pumps, oil coolers, and filters. Generally, it should be possible to pull tube bundles of all the oil coolers in one direction. Oil pumps should be arranged so that they can be worked on conveniently or at least can be removed from the system and taken to the shop for maintenance work. Oil filters should also be conveniently located so that they can be inspected, and cartridges or whatever is necessary can be changed.

It is strongly recommended that space be allocated in the general machine room layout for the auxiliary equipment with adequate clearance about the major components.

The auxiliary equipment frequently requires as much or more maintenance work than the main compressor and driver. ##

Centrifugal Compressors

5. Specification and Selection

Orin A. Smith, Worthington Corporation, Harrison, N. J.

A SATISFACTORY INSTALLATION of centrifugal compressors in refinery and petrochemical services has its inception in the first specifications which are issued on the contemplated project. All of the factors which affect the design and operating characteristics of the centrifugal compressor must be carefully studied and analyzed in so far as possible before these specifications are written. It is impossible to present a complete outline of so-called "standard specifications" for centrifugal compressors, since there are many applications which would involve special design and installation details of their own. However, it is possible to outline the most essential data required to prepare intelligent specifications, and experience and previous contact with centrifugal compressor applications will serve as a further guide on which to expand these data.

Table 1 summarizes the essential data required by a centrifugal compressor vendor, and the items are discussed more fully below in the order in which they are listed in the table.

The usual practice when compiling these data into a specification is to so arrange the wording and intent that each vendor shall have an equal opportunity to offer centrifugal compressors in accordance with the specification. Therefore, the discussion of the items to follow is offered merely as a general guide to the specification of centrifugal compressors, and as such does not represent the actual practice of any particular vendor or purchaser of centrifugal compressors.

General Data

Specification information under this broad heading should give the vendor a complete picture of the scope of the job, not only of the compressor itself, but also of the system in which the compressor is to operate. The design and operating conditions under which the compressor must work should be stated: the actual conditions which will be obtained at the compressor suction and discharge nozzle flanges, all piping, orifice, filter and other system losses will have to be taken into account to obtain the actual gas pressures at the compressor, and heat loss or gain through the compressor suction and discharge lines must be obtained and applied to give the correct gas temperatures at the compressor.

Gas compositions are usually expressed in mol percent, and the gas molecular weights and physical constants must be given for all gas streams entering the compressor, as well as the corresponding pressures and temperatures. State any abnormal operating conditions to be expected either during system upsets or compressor startups or shutdowns, and if the gas system design pressure is different from the compressor operating pressures state this pressure also.

The compressor driver is generally fixed by either the type of power available or the overall plant load factor; state whether the purchaser or the vendor will supply the driver. If the vendor is to supply the driver and an electric motor is indicated, state the motor type and the housing together with complete electrical characteristics including a limiting current inrush if necessary. Except in the cases where compressors can be run at motor speeds, a step-up gear will be required with a motor drive and should be so specified. If a steam turbine is to drive the compressor, specify complete steam inlet and exhaust conditions, together with mechanical details such as location of nozzles, type of governor and regulation desired, materials of construction if determined,

TABLE 1

SUMMARY OF ESSENTIAL SPECIFICATION DATA REQUIRED BY A CENTRIFUGAL COMPRESSOR VENDOR

I. **General Data**
1. Number of units required.
2. Design and operating conditions.
3. Driver type.
4. Submission of proposals, drawings, instruction books.
5. Guarantees, test, inspection.

II. **General Design and Materials**
1. Casing.
2. Rotor.
3. Volutes or diaphragms.
4. Labyrinth and seals.
5. Bearings and lubrication.
6. Baseplate, coupling and miscellaneous items.
7. Controls and instruments.

III. **Shipment and Storage**
1. Complete compressors.
2. Spare parts.

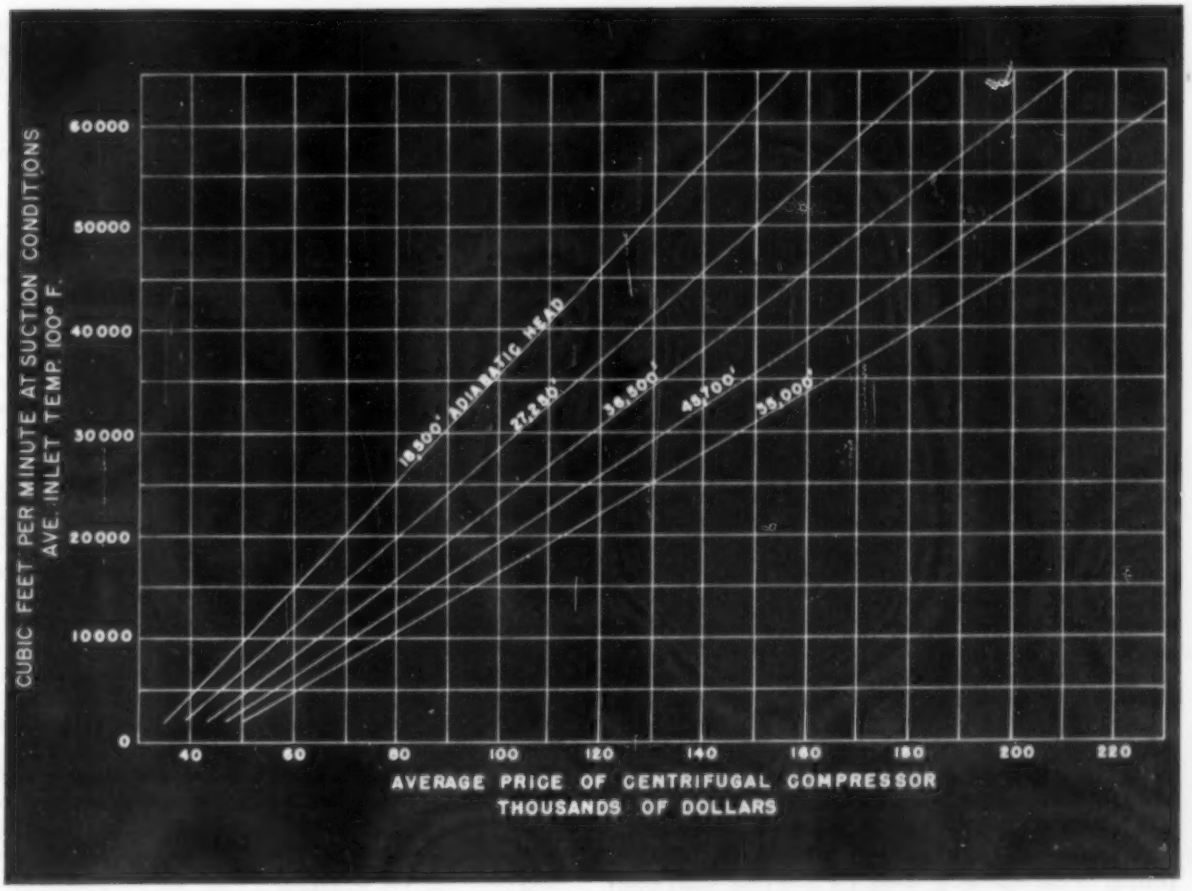

Figure 1. Present average compressor prices based on the physical size of the compressor.

oil system details, etc. If turbine bleed nozzles are required to furnish intermediate pressure process steam, state the steam pressures required. The purchaser should request the WR^2 of the compressor rotor if he is furnishing the driver.

The purchaser should state what items are required for the requested proposal and should set a realistic date for the submission of proposals. Proposals usually include preliminary compressor outline and typical cross section drawings, along with compressor performance curves at varying operating conditions showing the limit of stable operation. The proposal should also state such items as compressor size, number and diameter of stages, rotor and bearing dimensions, stiff or flexible shaft, materials of construction, details of lube oil system and shaft seals, maximum operating pressure and temperature of casing, and weight of equipment. Exceptions to the specifications should be listed in the proposal. Prices as quoted should include freight to delivery point; extra prices should be requested on witness tests, spare parts and the services of an erection superintendent.

Delivery should be requested from date of receipt of full manufacturing information.

The specification should include the number of certified drawings and instruction books required and the date of submittal of the certified drawings. Instruction books should be furnished by the vendor before shipment of the compressor.

The compressor should be guaranteed for one year after being placed in operation, but not more than 18 months after the shipping date. Any defective parts or equipment found within this period should be replaced by the vendor without charge.

Compressor performance at the design points should be guaranteed, with a tolerance of ± 4 percent on speed and horsepower.

The compressor casing and all other pressure cavities should be hydrostatic tested at 1½ times the design pressure for a time sufficient to allow examination of all parts being tested. The complete compressor should be given an air performance test at as near design conditions as possible to obtain data for performance curves and to check for satisfactory mechanical operation. If inspection of the above tests by the purchaser is requested, the vendor should be required to notify the purchaser's inspector at least five days prior to the date of the tests.

General Design and Materials

The largest portion of centrifugal compressor applications are for operating conditions which require the vendor's standard designs and materials of construction.

Specification and Selection . . .

In general, this information can be obtained from bulletins and sales literature, and the following is merely a compilation of universally accepted design features and materials of construction.

Compressor casings are of the horizontally split type, with gasketed or metal-to-metal joints suitable for the pressures and temperatures to be encountered. Lifting lugs and casing stage drain connections should be furnished, together with appropriate flushing oil connections if required. Construction should be of a one piece steel casting for each half, or of individual components, such as nozzles, casing ends, etc., joined by welding. Suction and discharge nozzles are usually ASA design with equal pressure ratings. Casing bolting should be of high tensile steel suitable for the operating temperatures.

The compressor rotor, in common parlance, includes all rotating parts, of which the most important are the impellers and the shaft. The impellers should be of the closed type (having both front and rear shrouds or covers) and made of low alloy steel. Both cast and fabricated or built-up constructions are acceptable for all operating conditions. Impellers should be examined by X-ray and/or dye penetrant or magnetic particle methods, statically and/or dynamically balanced, and given an overspeed test of at least 115 percent of the operating speed.

Shafts should be of heat treated and stress relieved forged alloy steel, with uniformly fine finish all over. The shaft design should be such that the first critical speed is at least 120 percent of the operating speed for a stiff shaft compressor, and between 35-40 percent or 55-65 percent of the operating speed for a flexible shaft compressor. Steel shaft sleeves should be furnished at labyrinth or pressure-breakdown points with close running clearances.

To minimize axial rotor thrust loads during operation, an alloy steel balancing drum or piston should be affixed to the shaft adjacent to the last stage impeller.

The completely assembled rotor should be accurately dynamically balanced so that vibration at the maximum operating speed is not greater than .002 inch total amplitude as measured on the shaft or bearing housings.

Volutes or diaphragms for internal guidance of the gas should be horizontally split, of good quality cast iron, with close-fitting metal-to-metal joints to minimize interstage leakage. If liquid cooled diaphragms are required, each half should have separate cooling passageways, with inlet and outlet connections manifolded at the top and bottom of the compressor casing.

All internal close clearance points should have renewable metallic labyrinth seals to minimize interstage leakage. Labyrinth material must be suitable for the gas being handled, but generally lead-bronze or aluminum is employed.

Suitable seals should be provided where the shaft passes through the compressor casing to the atmosphere, and they should be accessible for inspection without removing the top half of the casing. Metallic labyrinth or carbon ring seals should be provided with an automatically regulated eductor system if the compressor suction pressure is above atmospheric, or an automatically regulated injection system if the compressor suction pressure is below atmospheric. If furnished, oil seals with sealing rings or bushings should be complete with the necessary seal oil system and its associated regulating and protective devices, and means should be provided to prevent oil loss into the compressor.

The compressor rotor should be carried in full journal type main bearings, spherically seated and with positive pressure lubrication. Replaceable bearing bushings or liners may be used. Axial thrust load of the rotor in either direction should be accommodated by a kingsbury type thrust bearing or its equal, also with positive pressure lubrication. Leakage of corrosive gases through the shaft seals into the bearing housings should be held to a minimum.

Bearing lubrication should be furnished either by the driver lubricating system or by an integral compressor lubricating system, to be complete with main and auxiliary oil pumps, oil reservoir, coolers, filters and necessary interconnecting piping together with regulating and protective devices.

The compressor baseplate should be of fabricated steel construction and may or may not have provisions for mounting the driver and other auxiliary equipment. It should be machined to provide smooth surfaces for mounting equipment.

Couplings should be forged steel, of "flexible" design and generally with a spacer sleeve between the coupling hubs. For high speed operation the couplings should be dynamically balanced and match marked.

Rotation arrows should be prominently displayed on the compressor case and if feasible on auxiliary rotating equipment.

All special tools required for maintenance work on the compressor should be supplied with the compressor by the vendor.

Compressor controls and instruments in general fall into the categories of indicating or controlling, and may be hydraulically or pneumatically actuated. All controls and instruments for the safe and proper operation of the compressor should be supplied by the vendor, unless the specifications state otherwise. Instruments may or may not be mounted on a control panel.

Shipment and Storage

Completed compressors and associated equipment should have all unmachined surfaces painted and all machined surfaces slushed with a suitable rust preventive before shipment. All flanged openings should be covered by wood or metal flanges, and all threaded openings closed with standard pipe plugs. If required, packaging and crating of the compressor should be adequate for outdoor storage.

Compressor spare parts should be slushed and securely boxed, and should be either stamped or tagged with vendor's part numbers or item numbers and compressor number to facilitate identification.

Preliminary Price Estimates

The refinery estimator, during the preliminary stages of pricing a complete installation, can effectively use information on the approximate prices of the centrifugal compressors involved. The curves shown in Figure 1 present average compressor prices based on the physical size of the compressor, given as gas capacity in cubic feet per

minute at the compressor suction conditions, and on the adiabatic head of the compressor, given as feet of head of the gas being compressed.

Naturally, it is not possible to take into account all the factors which enter into a rigorous and accurate determination of the final selling price of a centrifugal compressor, and so the following assumptions were made to obtain these average price curves: (a) the inlet temperature of the gas being handled is 100 F., which is the average gas temperature obtained from the discharge of intercoolers, (b) the compressor discharge pressures are in the higher pressure ranges, up to 300 psig and (c) the mechanical construction of the compressor is reasonably standard, utilizing metallic labyrinth type shaft seals and a steel casing. It was felt that these assumptions were general enough to cover the bulk of the usual refinery applications of centrifugal compressors.

When selecting the type of centrifugal compressor to be specified for a particular application, it is necessary to consider all of the applicable factors involved and to judge the relative effect of each on the compressor. Consider first the type of gas to be compressed and its effect on the compressor. The thermodynamic characteristics of this gas or the process limitations will dictate what the suction and discharge pressures of the compressor will be at operating conditions. However, if the process shuts down for some reason and attains a temperature equal to the atmospheric ambient temperature, what pressure will the gas attain? In the case of ethylene or ethane, for instance, the so-called "equalization pressures" become quite high and dictate the use of high-pressure compressor casings, or else a blow-off or vent to limit the pressure which can be built up in the system.

If the gas to be handled is toxic or explosive, suitable sealing of the compressor must be provided so that danger and injury to the operating personnel is considered a practically negligible factor. Corrosive gases must be so sealed in the compressor that there is a minimum of gas flow into the bearing housings, thus insuring a minimum of contamination of the bearing lubricating oil.

It is also necessary to make allowances on the metal thicknesses of the compressor parts exposed to a corrosive gas to allow for the corrosion effects.

If the gas is to come to the compressor from a packed tower or from a catalyst bed, and there is any chance of carryover of solid particles, then special care must be observed so that these particles in the gas stream do not contaminate either the compressor seal system or the bearing lubrication system. The usual design practice would dictate at least an inert gas shaft seal to effectively isolate the compressor bearings and/or the compressor oil seal system.

Special gas mixtures must sometimes be kept below a certain fixed temperature during compression to prevent copolymerization of the gas constituents, or in other cases the partial pressure of one or more of the gas constituents must be held below a fixed pressure. The compressor will usually be found to deliver too high a discharge temperature in such cases unless recourse is had to cooling the gas during the compression cycle. This can be accomplished in the following ways, each of which requires a different type of compressor design. The gas may be compressed up to the temperature limit in an uncooled compressor, then bled from the compressor casing, put through an external intercooler, and reintroduced into the compressor casing to be compressed through the following stages. Another means of accomplishing the same result is to use a "cooled" compressor, in which the interstage diaphragms are designed to have a liquid cooling medium circulating through them, thus removing a proportion of the heat of compression at each stage. Cooling of the gas stream during compression can also be very effectively accomplished by direct liquid injection into the compressor, in which the high latent heat of evaporation of the injected liquid is utilized to cool the gas by direct contact, in some cases almost down to the saturation temperature.

Compressors operating in a system in which there are shells, such as economizers, evaporators and condensers, containing appreciable amounts of stored liquid while in operation must be protected against excessive liquid carryover. Large amounts of liquid suddenly slugging into the compressor can impose tremendous loads and stresses in the rotating elements. In the case of refrigerant systems where liquids at temperatures as low as minus 100 or minus 150 F. are encountered, this excessive carryover into the compressor can induce thermal shock of such extreme proportions that the compressor internals on the warmer end (discharge) may fail completely. Carryover in large quantities may be effectively suppressed by the use of suction traps or surge drums of ample proportions with high liquid level alarm and compressor shutdown protective devices.

The final location of the compressor in the plant will have its effect on the design of the compressor and its auxiliaries. For instance, a unit which is to be installed in an outdoor location will require design refinements which would not be necessary if it were located under cover. Means must be provided to prevent the entrance of rain, snow and dirt into the compressor bearing housings or the couplings, and the same precautions must also be observed on the compressor auxiliaries such as the oil pumps, their drivers, etc. No such design features would be needed for an indoor compressor installation. If it is considered desirable from a safety standpoint to so design the plant that there are no low-lying pipe trenches or other areas to collect explosive fumes, then the compressors can be located only on the main floor slab with top suction and discharge nozzles, or suitable structural members must be used to raise the compressors to such an elevation that bottom suction and discharge nozzles can be used and still have the connecting piping above the main floor slab.

These few comments on the context of centrifugal compressor specifications and on some of the factors entering into the selection of the type of compressor should serve as a base upon which refiners and their engineering, specification and purchasing departments may effectively increase their knowledge of this high speed, high performance equipment, and therefore, be better able to specify and purchase centrifugal compressors. ##

Centrifugal Compressors

6. Operation and Maintenance

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THE FIRST AND MOST important step in getting a centrifugal compressor into successful operation, with high availability over a long period of time, is to insure that it is installed properly. A manufacturer's outline drawing should give all data necessary for erection of the machine. Foundations may be structural steel or concrete, but in neither case should they be rigidly connected to the floor or other parts of the building, since this may greatly amplify normal vibration of the compressor. Any supporting structure must be sufficiently rigid to prevent excessive deflection of its members and must also be braced to prohibit sway. The type of foundation and its design will depend upon local soil conditions as well as space available and economics of the various foundation types. However, foundation specialists should be consulted to insure that any contemplated supporting structure is suitable and falls within the above very general limitations.

The complete unit's base plate, or individual sole plates for compressor and driver, should be aligned before grouting in on a concrete sub-base or anchoring to structural steel supporting members in order to provide a proper basis for alignment and leveling of compressor and driver shafts. As the unit is erected, particular attention should be paid to coupling alignment, with allowances made for changes which will occur as the machine comes up to operating temperature.

Main intake and discharge piping connections to and from the compressor must be arranged in such a manner that a minimum of stress is transmitted to the compressor casing via the piping due to either weight or expansion. This means the pipe flanges adjacent to the unit have to be aligned and parallel, and that the piping must be supported with provision for thermal expansion, without exerting a total strain on the compressor casing of more than just a very small percentage of the weight of the machine. Precaution should be taken if expansion joints are used since these do not necessarily reduce piping strains to a reasonable magnitude unless the pressure forces exerted by the expansion joint are compensated for and the spring forces are considered. If the piping is not analyzed carefully and stresses relieved to reasonable values, trouble can be expected with casing distortion, bearings, shaft misalignment, vibration and generally rough operation.

The lubricating oil system (and seal system, if any) has to be completely clean and free from dirt, rust, scale or any other foreign materials, and after cleaning must be protected by rust preventatives to prohibit further deterioration before the unit goes into service. One way of doing this is to flush the system with a light turbine oil, preferably through a fine filter. Clean the oil strainers and filters frequently until the system is free of foreign materials. Remove all bearing shells and check the entire bearing assembly to be sure they are clean. All deposits which may have accumulated on the bottom of the oil reservoir also must be removed.

Start-up Procedures

Discussion here will be confined to the compressor only and neglect start-up procedure of drivers since these fall into many categories, each with its own particular requirements.

Before starting the centrifugal compressor, alignment and clearance between rotor and stationary elements should be checked by turning the rotor by hand. Both the compressor and driver rotor should turn freely when tried separately or when coupled together. Rotation should be double checked if the unit is motor driven. It is recommended that this be done before coupling the motor to the compressor since serious damage may result if the machine is run backward even for a few minutes.

Inlet piping inspection will reveal if any foreign matter is present and which would cause serious damage if drawn into the compressor. Determine if there are any low spots in the piping where liquids can collect, and if so, have these low spots drained, with provision to keep the areas continually free of liquids. This is particularly important on units in hydrocarbon gas service. The compressor casing itself should be drained before starting, as well as the intake piping.

The lube oil reservoir is to be filled to the correct level with a grade of oil recommended by the manufacturer. Place the auxiliary lube oil pump in operation so the bearings will be receiving circulated oil under pressure prior to start-up. If the machine is equipped with twin oil coolers, strainers or any other duplex equipment in the lubrication system, make certain that both sides are completely filled with oil. This will prevent trip-out or possible bearing failure due to low oil pressure resulting from switchover, during operation, to a cham-

ber containing air at atmospheric pressure. After the coolers, strainers and piping are completely filled with oil, examine the oil reservoir for a final check on the oil level, making sure it is filled to the proper point.

If the compressor has a seal system, either oil or gas operated, put this into operation in accordance with the manufacturer's instructions. It is beyond the scope of this article to present even "typical" instructions for starting a seal system since seal design and components of the accompanying system may vary considerably between manufacturers.

Coupling lubrication should be added if it is a type where this is required. The joint between the two halves and the filling plug must be absolutely tight. A white sheet of paper held near the coupling, while running, will indicate even a slight leak. If this precaution is not observed, the lubricant may leak out and result in excessive wear, with eventual failure.

On motor driven compressors, it is necessary that the intake valve (and by-pass line, if any) be closed to prevent overloading the motor during acceleration. As soon as the unit reaches full speed, this valve must be opened immediately to a point where the compressor is operating above the unstable capacity range. If the compressor is allowed to operate for any length of time with the intake closed, the temperature inside the casing will rise to a very dangerous level.

After the compressor reaches full speed, shaft vibration should be quickly checked, and if found to be excessive, the unit shut down immediately to determine the cause. Among the most common causes of excess vibration are: contact between rotor and labyrinth packing rings, misalignment, improper bearing clearances, unbalance, or improper mechanical seal clearances. Since rotors are balanced and tested at full speed before shipment, trouble from this source is rarely experienced. However, it is possible to destroy the balance of a rotor through mishandling, deposits of foreign material, or even corrosion or erosion of the impellers.

If operation appears to be satisfactory, the compressor should be left running a sufficient length of time for bearing temperatures to level off and the casing to come up to normal operating temperature. Examine the unit for oil leaks and other minor difficulties. After temperatures have leveled off, arrangements should be made to shut down for a hot coupling alignment check and this must be well prepared for in advance. It must be done with the utmost speed since the machine will cool off rapidly. Take this opportunity to inspect bearings throughout the unit and dress up any slight high spots that may show up on the bearing surfaces. After reassembly, the compressor is ready to be put on stream after again taking proper precautions to remove any liquid from the intake line and the casing itself.

If the centrifugal compressor is driven by a variable speed driver, the critical speed, if any, should be determined so that the unit may be brought up to full speed with particular attention paid to running through the critical speed range as quickly as possible. This will avoid the possibility of damage to internal parts of the machine due to excessive vibration at the critical speed.

Some special operations are required to get a centrifugal compressor on the line if it is to operate in parallel with other units. However, this may not at first be obvious without reviewing briefly the characteristics of a centrifugal compressor.

Assume the compressor is operating at constant speed and capacity is reduced, by throttling at the discharge, from normal capacity to lesser values. The discharge pressure will increase as the unit "backs up" along its characteristic curve. If capacity is further reduced by increased throttling, flow will not be steady but intermittent because of operation in the unstable range. Use of a check valve in the blower discharge will decrease the magnitude of the pulsations but will not stop them. The capacity at which this breakdown of flow occurs is called the pumping limit. If the discharge valve is completely closed, pulsations become less violent but of higher frequency and the shut-off pressure is lower than the design operating discharge pressure.

From this, it is apparent that once a unit is "off-the-line" it cannot get back on or get on initially because of the drop in pressure at shut off mentioned above. To put a centrifugal compressor on the line in parallel with other machines, it is necessary to either drop line pressure (by throttling the intake or slowing down the other units) or by-pass or blow-off sufficient gas capacity of the unit being started to bring it up into its stable operating range.

Operation

The normal operation of a centrifugal compressor is very simple if it has been erected and started correctly. It is very desirable from both an operational and mainte-

Refinery Turnarounds

are coming in for thorough treatment next March. The most complete coverage of this subject ever to appear in print—from the determination of when to have a turnaround to the tightening of the last bolt—will be presented.

In these days of high inventories and stiff competition, maintenance costs are assuming critical importance, and this Maintenance. Special Issue will spell out ways of improving the efficiency and decreasing the cost of this important maintenance function.

Watch for it in the March issue of

Petroleum REFINER

nance standpoint to have a complete log of the operating and mechanical conditions taken at regular intervals. This log should include intake pressure, intake temperature, intake volume, discharge pressure, discharge temperature, rpm, bearing oil inlet temperature, bearing oil pressure and bearing oil drain temperature. Also, the level and condition of the oil in the reservoir should be checked regularly, particularly for the presence of water. Unless the oil is in first class condition, satisfactory operation cannot be expected from this class of mechanical equipment.

It is especially important to watch bearing oil temperatures and pressures closely during the first few days that a unit is first put into service. The oil strainer should be cleaned frequently for the first few weeks of operation and until all foreign matter that may possibly have remained in the lubrication system has been removed. Oil coolers will have to be cleaned occasionally to maintain good heat transfer. Only clean water should be used in the coolers.

The lubricant, if any, in the coupling should be checked periodically since it is most important that the coupling have the proper amount of lubrication at all times. After each examination, the tightness of the joint and filler plug should be checked as on initial start-up.

If the compressor runs for several months without shutting down, then the auxiliary oil pump should be manually started on occasions to insure that it will function if called upon to do so.

If the machine is operating in parallel with other compressors, care must be taken to prevent possible backflow of gas through the unit in the event of power failure. Such a backflow will cause reverse rotation with probable bearing damage and with possible dangerous overspeeding. A discharge check valve is normally used as a safety device to prevent backflow, and it also will help in getting the machine on the line as illustrated under "Start-Up Procedures."

Inlet solvent sprays and interstage spraying are sometimes a necessary evil required to remove or prevent the accumulation of deposits in the impeller and gas passages. The composition, amount and frequency of the spraying depends upon the nature and rate of build-up of deposits. Any spray should be thoroughly atomized to prevent solid streams of liquids from entering the unit. It should be remembered that the introduction of liquids into a compressor, no matter how finely atomized, will create problems of drainage and erosion. Drain provisions must be made to prevent the build-up of liquid level inside of the casing as this may result in the collected liquid passing through the unit in slugs. The rate of erosion is a function of the liquid particle size, the quantity of liquid injected and time. A close check of these variables must be made to be sure that the spray quantity and frequency of spraying is held to the absolute minimum consistent with the cleaning requirements.

Stopping

After the compressor has come to rest, the main inlet and discharge block valves should be closed. It is advisable to run the auxiliary oil pump for several hours after stopping the compressor, allowing accumulated shaft heat to become dissipated as the unit cools off. The casing is usually purged with inert gas or steam before taking the seal system (if any) out of operation in accordance with the manufacturer's instructions.

In the case of machines handling very dirty or polymer-forming gas, it may be advisable to open the unit and thoroughly clean the casing and rotor when taking the unit out of service. This practice will eliminate any of the usual difficulties encountered when starting up a centrifugal unit in which deposits have been allowed to accumulate. Such a procedure depends upon local conditions and no set rule can be made.

Maintenance

In general, maintenance is inseparably tied in with operation, and the best form of preventative maintenance is proper installation, starting, stopping and operation of the compressor, keeping the unit clean both inside and outside during operation. At regular intervals, the centrifugal compressor unit should undergo a general and thoroug' inspection. The length of time between inspections can best be determined by local operating conditions, and although some machines have been run for several years without being examined, this period is much too long. Something in the order of one year more closely approaches the normal interval.

The rotor should be taken out of the casing to have all deposits removed as well as to determine the degree and rate of corrosion or erosion. The coupling should be inspected for wear and cleanliness. Thoroughly clean the casing, noting carefully the condition of all labyrinth packing rings, bearing shells and thrust blocks. The oil reservoir, oil strainers, oil coolers and bearing bodies should be drained and cleaned. If the oil is still in serviceable condition, it can be filtered and re-used. Upon reassembly, care must be taken that tools and other objects are not left in the compressor casing or connected piping.

It will probably be necessary to carry certain compressor wearing parts in stock as spares. The extent to which these spare parts may be justified is entirely dependent upon the degree of wear expected, replacement time, and the value of shut-down time. Certain basic items such as bearing liners or shells and packing are normally carried in stock, but the manufacturer's list of recommended spare parts should be used as a guide to determine what is or is not an absolute necessity.

Long Period Shut-down

If a prolonged shut-down is required, it is necessary to protect the bearings, rotor and finished surfaces of the compressor from the action of the gas normally handled and also from atmospheric deterioration. How this is handled depends on the length of shut-down time required and local conditions. Various protective compounds are available and their use is dictated by the recommendations of the suppliers. Care should be taken to prevent condensation of moisture on the finished parts. The lubricating oil system should be drained, flushed clean and then refilled with clean oil; however, the water system, if any, ought to be completely drained and left open. ##

7. Seals and Sealing Systems

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MORE AND MORE frequently, the sales forces of compressor manufacturers ask the designer "What seal shall we offer for this proposal?" It is evident that there is an increasing need for new and better sealing arrangements as the result of increasing use of centrifugal compressors in new applications.

The shaft seal is being recognized by the producer as one of the most important and critical parts in centrifugal compressors. The designer has at his immediate disposal a wide selection of sealing elements and systems that can be satisfactorily applied to installations handling refinery gases, natural gas, toxic and rare gases under conditions of our modern high speeds and pressures. The consumer is aware of this progress and is becoming more willing to purchase compressors for new applications with ultimate savings in capital investment and operating costs.

This rapid progress in seal development has been made only in the last few years and an up-to-date review of available seals and sealing systems should be of general interest. To present this review briefly, one designer's evaluation and approach to the sealing of centrifugal compressors is given.

Single Direct Acting Seals—A first consideration in almost any gas sealing problem would be given to the possibility of using a *Labyrinth Seal*. Its low cost and reliability are a goal to be approached by all other designs. However, it does permit considerable leakage of the gas being handled. Several design forms of the labyrinth principle have been developed to minimize this leakage. The straight pass labyrinth is basic and would be incorporated in a low cost, low pressure air or flue gas compressor. The staggered labyrinth would be selected for applications having higher pressures. A floating segmental type labyrinth would be more efficient in compressors handling high temperature air or exhaust gas since its construction minimizes the effects of thermal expansions by maintaining almost constant clearances throughout the temperature range.

The designer views the labyrinth seal as a fundamental and simple device. He thinks of it as merely a restriction to the flow of gas and analogous to an orifice in a pipe. Technically, it acts as a seal by breaking down the gas pressure through velocity head dissipation and its leakage roughly follows the laws of orifice flow. Leakage is dependent primarily upon clearances between the knife points and the shaft, and secondly, between sharpness of the points, pitch and depth of the knives for given gas properties and pressure. For many years, the flow through labyrinths has been reliably calculated by the method suggested by Adolph Egli (Trans. ASME, April, 1935).

Clearances of the fixed type of labyrinth seals are dependent upon manufacturing tolerances and eccentricities. They are affected by journal bearing clearances, thermal expansions and vibration of unit under operation. The clearance is usually sized so that a slight interference between the knife points and the shaft is possible during the run-in period, but inevitably increases to at least .015" and more particularly with compressors that must run through a lateral critical frequency to achieve operating speed. For comparing leakages to be expected with all types of seals, the straight pass labyrinth is given the base index of 100. See Table 1.

The second consideration may be a gland box containing *Segmental Carbon Ring Seal* elements. The segmental carbon ring has been used extensively on steam turbines throughout many years in place of labyrinth seals for the purpose of minimizing leakage and conserving space and shaft length. Its design has, in general, taken two forms, one of which is shown in Figure 1. The ring shown in Figure 1 is a patented design, and offers a means of supporting its own weight once it has arrived at its proper operating position. Wear is consequently reduced and life increased.

Use of the segmental carbon ring is viewed by the designer for applications where the gas being compressed is relatively free of dirt and debris. Its potential has not been exploited in this country as it has been abroad where applications exist having pressure differentials as high as 150 psi across each carbon ring. Designers consider it feasible for use on flexible shaft machines where it responds without damage to radial oscillations when the unit is passing through a critical frequency. The clearances are not increased as would be the case as a labyrinth seal. Further consideration would be given for applications requiring low leakage where ambient temperatures at the seal would be high. The clearances between ring and shaft decrease with an increase in temperature and consequently offer a characteristic just opposite to a labyrinth. This characteristic is self-evident when considering that the thermal co-efficient of expansion of the carbon ring is only one-fourth that of the steel shaft whereas the thermal co-efficient of expansion of a labyrinth material is usually 50 percent above that of the steel shaft.

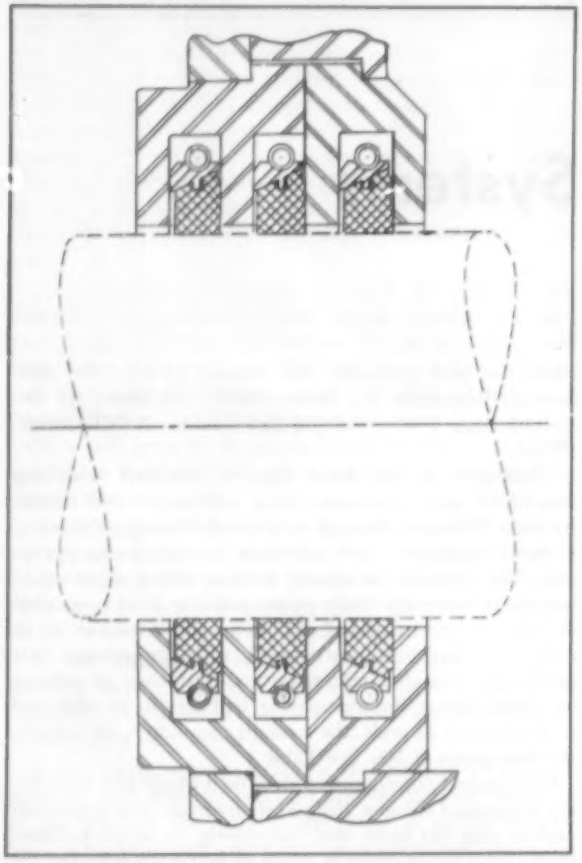

Figure 1. Self-Positioning patented segmental carbon ring.

In general, temperatures are limited by the oxidizing properties of the gas leakage. For example: with air, temperatures should be below 600 F., and with steam, 900 F. Their use in compressors having shaft speeds at the seal of 15,000 feet per minute, or more, is feasible.

Leakage is a function of clearances, gland width and number of rings for given gas properties and pressure. The designed clearances are usually maintained throughout the run-in period of a machine and increase slowly with time, depending upon the degree of abrasive contamination contained in the leakage gas. In general, seal life of two to three years continuous operation should be expected. A carbon ring functions as a restriction to gas leakage in dissipating the gas pressure by friction along its clearance walls. Its principle is analogous to the pressure drop effected by friction through a long small bored pipe. As a rule of thumb in preliminary consideration of carbon rings for an application, the expected leakage would be less than 25 percent of that of a well designed labyrinth, occupying the same axial space. See Table 1.

A most important advantage of segmental carbon ring seal designs and the labyrinth designs lies in their ease of inspection and replacement which requires only removal of a cap and slipping out the segmental elements. Costs of carbon ring assemblies throughout the years have been reduced through the standardization of rings by various manufacturers. However, the gland box into which the carbon rings are positioned is usually a tailored design and its cost will vary with the quantity produced.

Although the carbon rings possess many inherent advantages, their use as a single sealing element directly against the compressed gas is limited principally by the fact that most applications handle dirty gas. Their greatest potential is as a double element, or in combination with other types of seals when used with a sealing system that supplies a clean leakage gas as described further on.

A relatively new consideration is possible with the advanced development of the *Contact Type Seal*, one variation of which is shown in Figure 2. Contact seal designs consist of a shoulder or collar affixed to the shaft and a non-rotating seal ring positioned against the collar by springs. This arrangement has been used for many years as a fluid seal in centrifugal pumps. A careful and exhaustive study of its design has proved its use in sealing gases without fluid lubricant or cooling. By thorough analysis of forces controlling the mating pressure between stationary and rotating elements, together with developments in metallurgy and manufacturing techniques, the dry contact seals have operated successfully with pressures up to 400 psi at relatively low rubbing speeds, and at rubbing speeds under 25,000 feet per minute at pressures up to 100 psi. The sealing elements are usually made of a refined grade of carbon for the stationary seal ring and a stabilized hardened steel as the rotating ring. This combination naturally would have similar temperature limitations as are applied to the segmental carbon ring seal mentioned above.

Considerable attention has been given to achieving a rugged design. The carbon element should be given strength and rigidity by encasing the carbon material inside a shrunk steel ring. In addition, every attempt should be made to arrange the seal as a cartridge and avoid the necessity of handling the carbon element and the multiplicity of springs and internal parts during shipment and assembly.

Its outstanding advantages lie in its ability to effect an almost perfect seal. Its leakage is primarily affected by size and surface speed for a given pressure. In general, expected leakage would be less than 1/50 of a labyrinth seal occupying about the same space. See Table 1 for comparison to other seal designs. It is almost unaffected by shaft vibrations and can be made to operate with slight axial movement of the shaft. Wear in applications with a clean gas will be less than .001 inch per 1000 hours and should offer a life expectancy up to 25,000 hours, or about three years of continuous operation.

The contact seal has been approached with reservation in view of its limited field record. It was first used on compressors in aircraft wind tunnel applications where efficient sealing of clean dry air was required. Its successful record for several years led to applications with

TABLE 1

Index of Relative Leakage for Single Sealing Elements

SEAL	Leakage Index
Straight Pass Labyrinth	100
Staggered Labyrinth	56
Segmental Carbon Rings	20
Dry Contact Seal	2

clean chemical process gas where leakage of valuable gas had to be minimized. The designer views this contact seal most favorably for applications having strict limitations on the permissible amount of gas leakage either in or out of the compressor and where external facilities or controls are particularly not desirable.

Sealing Systems—The above-mentioned seals, when used in pairs and in conjunction with sealing systems, as pictured in Figures 3 and 4, have been instrumental in sealing compressors handling explosive, toxic and very high pressure gases. It was not too long ago that, when a designer was asked to seal an explosive gas at 1000 psi from escaping between shaft and compressor casing, he would answer "weld it." Today, he will tackle sealing problems on gases having pressures many times higher.

A designer approaches sealing problems requiring complete sealing of gas from the environment surrounding the compressor by considering the simplest possible sealing system.

The *Evacuation System* shown in Figure 5 requires the use of two of the single sealing elements, either labyrinth, carbon rings or dry contact seals. It operates on the principle of sucking the gas from between the two seals, thereby reducing the pressure below both the pressure of the compressor gas at the seal and the atmospheric pressure so that no compressed gas escapes to the environment. Atmospheric air would, of course, leak in to the educted chamber and contaminate the compressed gas being blown off to the eductor. Now, depending upon whether or not the contamination of the compressor gas by air can be permitted, this educted gas would be introduced back into the compressor suction, or wasted by expelling it into the atmosphere through a flare pipe, Figure 5.

The selection of either labyrinth, carbon ring, or dry contact seal would be made upon the basis of permissible in-leakage of air, recirculating of gas leakage, abrasive particle contamination of gas, speeds, pressures and temperatures.

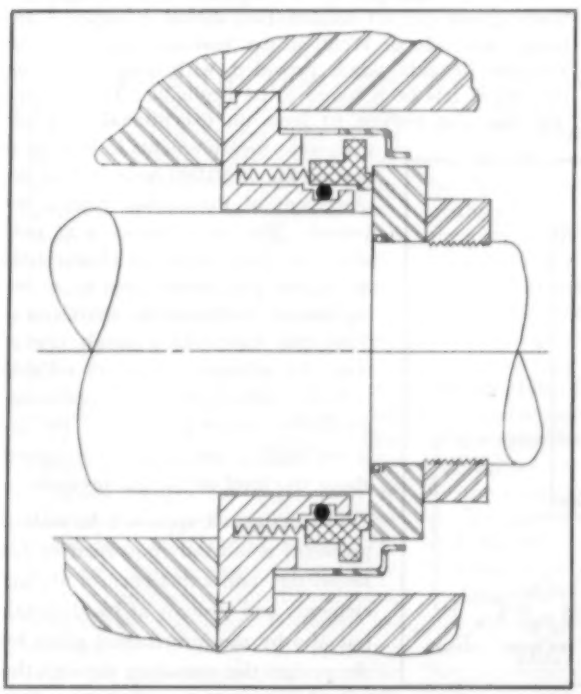

Figure 2. Contact seal.

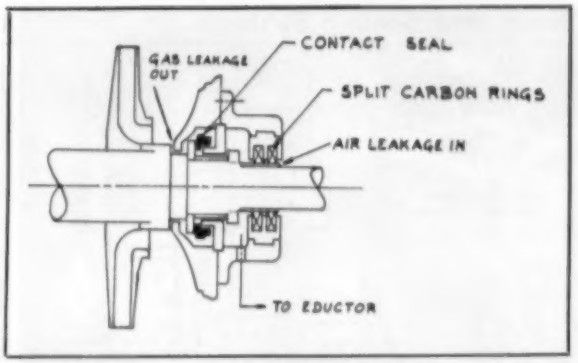

Figure 3. Double seals-contact and carbon rings for evacuation or gas injection systems.

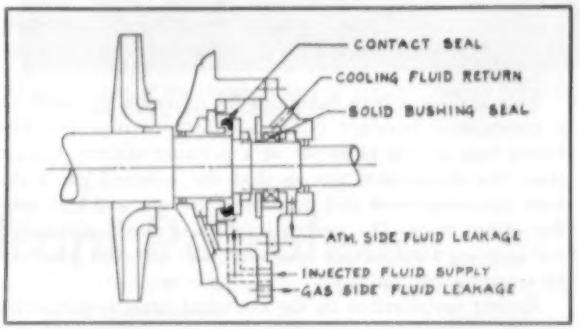

Figure 4. Double seals-contact and bushing for fluid injection system.

The eductor may be powered by either an outside facility such as air or steam, or by the pressurized compressor discharge gas. In either case, the designer must give every consideration to minimizing the horsepower loss incurred in recirculating gas upon which work has been expended. In typical cases, this loss may amount from 2 to 6 percent of the power required to drive the compressor, depending upon gas pressures and characteristics and size of installation. It would be evident that by minimizing the leakage quantities through consideration of carbon rings, or dry contact seals, this power loss would be diminished.

The eduction plan presents a great advantage in offering the possibility of a self-contained system relatively free of mechanically moving parts and low capital investment.

The *Gas Injection System* has been used by the refinery industries both here and abroad for many years as a means of totally sealing flammable and toxic gases from escaping between shaft and compressor casings. A typical system usually employs the use of double labyrinth sealing elements. Other combinations of single seals have

Centrifugal Compressors

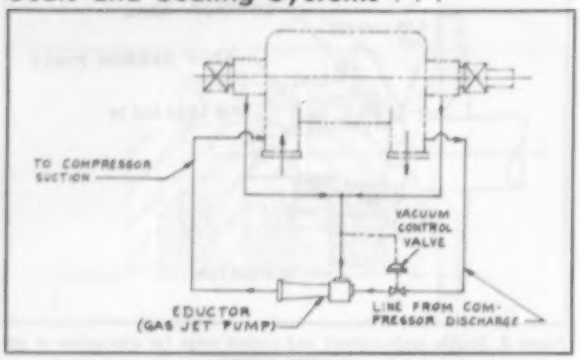

Figure 5. Evacuation system-self contained.

also been used, depending upon the allowable amounts of injection gas leaking to the atmosphere and into the compressor.

This sealing system functions by injecting gas such as a combustion product (CO_2 and air) or nitrogen, between two sealing elements at a pressure slightly higher than the compressor gas so that the injected gas leaks into the compressor and no compressor gas will leak into the atmosphere. The principle is particularly adaptable for utilizing the contact seal since the injected gas may be conveniently filtered.

Recent installations in the chemical process industries use this system in conjunction with the contact seal and segmental carbon ring assembly shown in Figure 3. Many thousands of hours of trouble-free service have been experienced to date.

The *Fluid Injection System* is an old established system which for many years has been used on low pressure gas compressors. Water at slightly higher pressures than the gas was interjected between two slinger or segmental ring type sealing elements and was allowed to leak both into the gas side of the compressor and into the atmosphere. The designer used this principle for high pressure and refinery applications because he found it unadvisable to employ the use of a dry seal. Its design is well known on pipe line installations and is being more frequently employed on cat cracker gas applications.

Combinations of two single sealing elements such as contact seals, bushings, or even segmental carbon rings used as fluid seals are employed. Oil is generally used as the injected fluid, although other fluids could be used as dictated by the specific requirements of the application. The oil is filtered, cooled, and pressurized to a pressure slightly above that of the gas pressure. Oil leakage usually results through both the atmospheric and gas sealing elements and is reclaimed and returned to the reservoir. In pipeline applications and other applications where the oil leaking to the gas side is not deleteriously contaminated by the gas, the oil may be used over and over again until the neutralization number indicates it is spent. In rare cases where the oil is exposed to a stronger toxic or sulphur gas, it may be discarded or reclaimed by outside facilities. By proper selection of a seal on the gas side, this exhausted oil would add only a few dollars per day to the operating cost of the installation.

Two combinations of sealing elements have been used most frequently with this fluid injection system. One is shown in Figure 4.

Designers may differ in their approach to selecting the sealing elements. One approach would be to evaluate the characteristics of each element for the specific function it is to perform and for location where it will be installed.

For example: on high-pressure applications, the desirable location for the bushing element is on the more rigid journal bearing side of the combination where angular deflections are negligible, and where appreciable oil leakages can be tolerated without exposure to the gas and can be easily drained and collected. On the gas side, the contact seal may be preferred in view of its characteristics of low leakage and insensitivity to shaft vibrations, particularly after machines have aged in operation.

Long life capacities of the injection system using the bushing and contact combination shown in Figure 4 are being experienced. Wear of the bushing placed on the atmospheric side when provided with ample rotating clearances has been found to be negligible. The contact seal has also proven to have an exceptional long life with wear measurements indicating a normal life of 50,000 hours before replacement of the carbon ring is required. The wet contact seal possesses the same desirable characteristics as the dry contact seal in its being almost unaffected by shaft vibrations and momentary rough operation. In addition, it offers reliable service under abnormal operating conditions where pressure of the injected fluid is not always maintained above the level of the gas pressure.

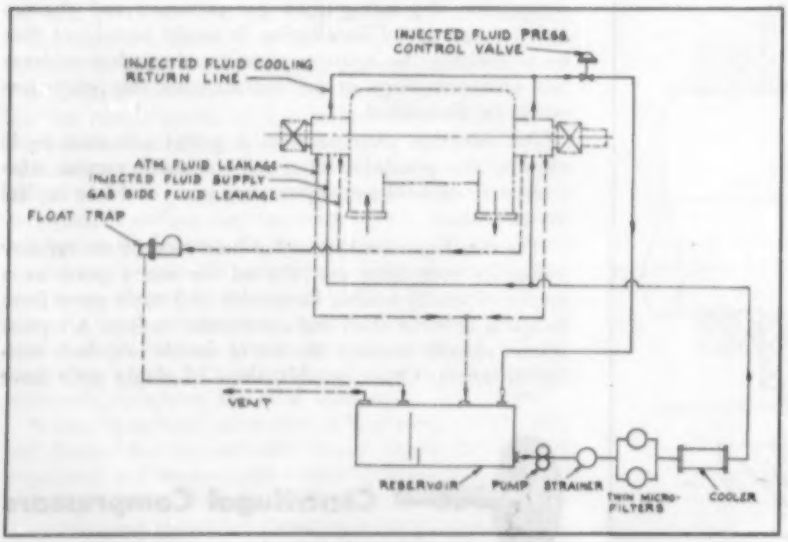

Figure 6. Fluid injection system.

The designer's approach to sealing problems is not only governed by his knowledge and experience of sealing elements and systems at his disposal, but also by the information given by the prospective consumer through the sales forces. ##

	Conversion Of Alcohols	Oxidation Of Hydrocarbons	Hydration Of Acetylene	Oxo Process	Fischer–Tropsch	Aldol Condensation And Dehydration (+ Hydrogenation)	Special Methods
Formaldehyde	X	X					
Acetaldehyde	X	X	X		(2)		(1)
Acrolein		X				X	
Propionaldehyde	X			(2)	(2)		
Crotonaldehyde						X	
Butyraldehyde	X			X	(2)	X	
Isobutyraldehyde	X			X			
C_5-C_9 Aldehydes	X			X		X	
Glyoxal	X						

(1) Acetaldehyde Is Also Produced (A) Via Ethylidene Diacetate (B) Via Vinyl Methyl Ether
(2) Feasible But Not Current Used On A Commerical Scale

Figure 1. Commercial routes to aliphatic aldehydes.

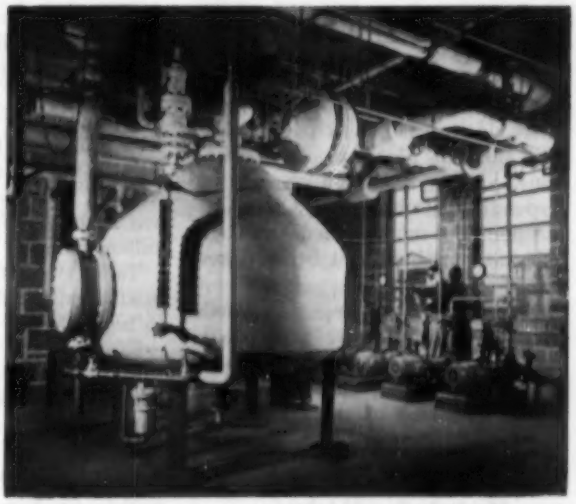

Figure 2. Part of the equipment used at Spencer Chemical Company's Calumet City plant producing formaldehyde from methanol.

Making Aldehydes from Petroleum

The first of a three-part series presents a comprehensive study of the various routes by which hydrocarbons are converted to aliphatic aldehydes in petrochemical plants. Part 1.

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White Plains, N. Y.

BETWEEN THE YEARS 1948 and 1953, formaldehyde production in the United States was nearly doubled. Acetaldehyde outputs rose by more than 50 percent. New methods of synthesis reached commercial maturity to help cover the rapidly growing demand for acrolein, n-butyraldehyde, and isobutyraldehyde. Propionaldehyde found new markets and may soon expect new sources.

Here, then, is a segment of the petrochemical industry which shows feverish activity—the aliphatic aldehydes.

Major outlets for this group of versatile intermediates exist in the production of plastics, rubber, explosives, surface coatings, synthetic textiles, antifreeze, organic solvents, plasticizers, and other customer industries. Seven commercial processes serve for their commercial synthesis from petroleum sources and an eighth is nearing realization.

Outdistancing its homologues in fields of usefulness is formaldehyde, the lowest member of the aldehyde family. It is derived primarily from methanol and its manufacture constitutes the largest single outlet (40 percent) for this alcohol. Smaller quantities of formaldehyde are produced by direct oxidation of hydrocarbons. In all, eighteen companies operate a combined total of twenty-six formaldehyde plants in the United States.

Acetaldehyde, the second member of the aldehyde family is first in production volume. It, too, is synthesized by the oxidation or dehydrogenation of its parent alcohol (i.e. ethanol) and by the partial combustion of hydrocarbons. A method of manufacture which is uniquely available to this member of the aldehyde family is the hydration of acetylene. Very large amounts of by-product acetaldehyde are formed in the course of gasoline synthesis by a modified Fischer-Tropsch process. This source of supply may be expected to take on real significance with the anticipated resumption of operations at the Brownsville, Texas, plant using this process.

Acrolein is today produced by two commercial routes—condensation of formaldehyde with acetaldehyde, and oxidation of propylene. A former method, the thermal cracking of diallylether, has been discontinued.

Propionaldehyde and the two butyraldehydes may be obtained by (a) oxidation of the corresponding alcohol, (b) partial combustion of hydrocarbons, (c) condensation of lower aldehydes followed by dehydration and hydrogenation of the resulting olefinic bond, (d) reaction of carbon monoxide and hydrogen with the next-lower olefin (Oxo synthesis), and (e) as a by-product of Fischer-Tropsch operations.

Aldehydes from Petroleum...

Higher aldehydes are produced, above all, by aldol condensation of lower aldehydes followed by dehydration (and, if necessary, hydrogenation), and by oxidation of the corresponding alcohol. Here, the Oxo reaction is of more limited usefulness for reasons which will be discussed below.

Thus, of the variety of methods available for commercial aldehyde synthesis, each (except acetylene hydration) serves for the production of several members of the family, but only one (namely the oxidation of alcohols) finds application for all.

Markets for Aldehydes

(a) **Formaldehyde** (H—C(=O)—H)—This commodity is normally sold as a 37 percent by weight aqueous solution. It has been shipped in concentrations as high as 50 percent but at these higher strengths special provision must be made to maintain the solution at elevated temperatures in order to prevent precipitation of insoluble polymer. Further difficulties may arise at strengths above 37 percent due to increase in acidity upon standing. To further suppress formaldehyde's tendency to spontaneous low-temperature polymerization a small amount of methanol inhibitor is permitted to be present where this is feasible.

For certain polymerization purposes, formaldehyde may be replaced by its trimer, paraformaldehyde. This product is a solid, which is shipped nearly dry, and therefore, with a significant freight saving. Acceptance of paraformaldehyde in lieu of its parent compound had reached 10 million pounds in 1952.

The United States entered World War II with a formaldehyde manufacturing capacity only slightly above 200 million pounds per year (37 percent by weight). Throughout the war years, formaldehyde was in acutely short supply, a situation which persisted until the nation's productive capacity for this commodity attained a level of 900 million pounds per year in early 1949. This milestone was quickly passed and actual output in 1951 was 988 million pounds. ODM's capacity goal of 1.67 billion pounds/year in 1955 was exceeded two years ahead of date. Installed capacity during the current year is estimated at 1.80 billion pounds per year, and additional facilities have been announced.

This degree of plant expansion has been fully justified by the growth rate of formaldehyde production. Average increase from 1946 to 1953 was at the rate of approximately 100 million pounds per year.

Table 1 will serve to illustrate the production trend over the years and to highlight the potential for future expansion.

Much of this output is captive. Of one billion pounds produced in 1952, only 550 million pounds formaldehyde was sold as such.

Outlets for formaldehyde lean most heavily on production of plastics (thermosetting resins) and surface coatings. Magnitude of the third-largest outlet, synthesis of hexamethylene tetramine, is heavily influenced by defense demands. The consumption pattern, exclusive of formaldehyde demand for ethylene glycol production, is outlined in Table 2.

In the production of phenolic resins, 37 percent formaldehyde is consumed at the average rate of 0.75 pounds per pound (exclusive of fillers and extenders). A good continuing growth potential is seen in this field. Phenolic plastics, which were first introduced in 1909, have maintained an important position in the face of growing competition from resins of more recent origin. Their continued wide acceptance is founded on low cost, high versatility, and outstanding physical characteristics.

The greater portion of phenolic resins goes into molded and cast end products ranging from electronic parts to washing machine agitators, baby toys, and pot handles. These markets consumed about 113 million pounds phenolic resin in 1953. Second in importance are applications for bonding and adhesive purposes. Seventy and one-half million pounds of phenolic resin entered this end use during the last year. Other important markets have been established in the manufacture of friction materials, thermal insulators, plywood, and in the formulation of protective coatings.

Over the years, phenol-formaldehyde resins have shown a good growth trend. Present forecasts look to a 1960 demand of 550 million pounds for the production of plastics alone. This is augmented by consumption in the formulation of surface coatings.

While the output of aminoplasts does not rival production of phenolics total consumption of formaldehyde in the manufacture of both is about the same. An amount of 1.45 pounds 37 percent formaldehyde is required for the production of one pound urea-formaldehyde resin, while melamine polymers have an average formaldehyde utilization of 0.85. Combined production of aminoplastics in 1953 was 247.6 million pounds. There is, at present, no development in view which might encourage hope for significant expansion during the coming years. Important growth during the past three years has been mainly in the categories of textile and paper treatment. Other established major applications include formulation into protective coatings, use as bonding agent for plywood production, and other adhesive applications. Melamine resins show outstanding properties for the production of plastic dishware, and urea-formaldehyde plastics have captured markets in the production of lamp shades, portable radios, scale housings, etc.

On a unit basis, hexamethylene tetramine is a heavy consumer of formaldehyde (3.6 lbs/lb). The bulk of this product goes into military applications.

Pentaerythritol, produced by the condensation of 4 moles formaldehyde

TABLE 1

YEAR	Formaldehyde Production (Million Lbs./Year. 37% Basis)
1940	180.9
1945	423.7
1950	835.1
1951	987.5
1952	1,022
1953	1,119
1954	1,370 (est'd.[1])
1955	1,500 (est'd.[1])
1960	1,900 (est'd.[2])
1975	8,000 (est'd.[2])

TABLE 2

Formaldehyde Consumption Pattern

(Millions of pounds, 37% basis)

	1949		1952		1953 (Est'd.)
	Million Lbs.	%	Million Lbs.	%	%
Phenolic resins	180	33	243	24	23
Urea resins	145	26	237	23	20
Melamine resins	25	4.5	50	5	4.5
Hexamethylene tetramine	33	6	198	19	18.5
Pentaerythritol	99	18	164	16	19
Miscellaneous	68	12.5	130	13	14
Total	550	....	1022	....	....

with one mole acetaldehyde is a polyhydric alcohol of growing importance in the production of alkyd resins for surface coatings. About 3.0 pounds formaldehyde is consumed per pound pentaerythritol produced.

One American manufacturer is engaged in the production of ethylene glycol from formaldehyde. The operation, which is competitive to the more widely practiced hydration of ethylene oxide, consumes approximately 1.75 pounds formaldehyde per pound product. While no official figures are available on the amount of ethylene glycol synthesized by this route, a fair estimate places annual output at 60-70 million pounds.

(b) **Acetaldehyde** ($CH_3-\overset{O}{\overset{\|}{C}}-H$)—On a dry basis, the production volume of this compound exceeds that of all other aldehydes. However, only a small portion enters trade channels as such. In 1948, when official production figures were last made available, U. S. output of acetaldehyde was 471 million pounds. Of this amount only 13.7 million pounds was sold. By 1953 production had risen to an estimated 725 million pounds and sales were reported at 34 million pounds.

More than 75 percent of all acetaldehyde production is converted directly to acetic acid and its anhydride. In this synthesis, acetaldehyde oxidation stands supreme above competitive routes such as acetone cracking, carbonylation of methanol, fermentation, and wood distillation.

Conversion to acetic anhydride constitutes a direct link between the production levels of acetaldehyde and of cellulose acetate (plastic or rayon). Indeed, this semi-synthetic polymer is the only important outlet for acetic anhydride and, both directly and indirectly, it also consumes the lion's share of the nation's acetic acid output. To produce one pound of cellulose acetate, about 1.7 pounds glacial acetic anhydride and 2.5 pounds acetic acid must be charged. Actually, only 0.5 pounds of the anhydride is utilized in the course of the process and the recoverable balance (3.5-3.5 pounds per pound product) is collected as dilute acetic acid.

In addition to utilization in cellulose acetate manufacture, acetic acid and anhydride find their way into the production of ethyl acetate and butyl acetate (solvents and plasticizers), acetyl salicylic acid (aspirin) acetanilide, acetylated castor oil (for use in brake fluids), and into diverse chemical syntheses of lesser scope. An important outlet for acetic acid exists in the production of vinyl acetate which, in its polymeric form, is of value in surface coatings.

The second-most important derivative of *acetaldehyde* is crotonaldehyde, intermediate in the production of n-butanol and butyraldehyde. It will be discussed below in further detail.

Chloral, obtained by the chlorination of acetaldehyde (and ethanol), finds its most important end use in the production of the insecticide DDT. Its output rose rapidly from 12 million pounds in 1948 to 25 million pounds in 1951 and declined to 20.8 million pounds in 1953.

Other notable applications for acetaldehyde include the manufacture of ethyl acetate (i.e. by a direct route), pentaerythritol (used chiefly for alkyd resin production) and methyl ethyl pyridine, an intermediate in the synthesis of nicotinic acid and of methyl vinyl pyridine (the latter is a monomer of value in imparting special dyeing properties to some synthetic fibers). Condensation polymers of acetaldehyde with phenol, aniline, and urea have found application in the plastics field.

(c) **Acrolein** ($CH_2=CH-\overset{O}{\overset{\|}{C}}-H$)—Acrolein-urea condensation polymers find application in textile finishing. By itself, the aldehyde has been used as lachrymator and as warning gas in refrigerant systems. It also serves as a raw material in the synthesis of methionine, a poultry feed additive of growing importance.

Various applications of value have been claimed for specialty lacquers and resins produced from acrolein polymerisates with phenol, polyvinyl alcohol, and pentaerythritol.

Acrolein derivatives offered in the United States include 2-formyl-2,3-dihydropyran (acrolein dimer), allylidene diacetate, ethyl-β-ethoxy propionate, 1,2,6 hexanetriol and a number of others.

(d) **Propionaldehyde** ($CH_3CH_2\overset{O}{\overset{\|}{C}}$)—Markets for this aldehyde are, at present, quite limited. It is used as disinfectant and in the production of rubber accelerators. A derivative of potential significance is trimethylol ethane which can serve in lieu of pentaerythritol in the production of alkyd resins. The compound is formed by condensation of propionaldehyde with two moles of formaldehyde.

Other suggested and actual uses for propionaldehyde parallel applications for its closest homologues acetaldehyde and butyraldehyde. Among them is the proposed use of polyvinyl propional resins as interlayer for safety glass. Phenol-propionaldehyde condensation polymers are claimed to be of value as demulsifying agents and as tackifiers for rubber.

Oxidation of propionaldehyde leads to propionic acid. Self-condensation yields propion-aldol which may be converted to α-methyl amyl alcohol, or to 2-methyl pentanediol, a plasticizer of some interest.

(e) **Crotonaldehyde** ($CH_3-CH=CH-\overset{O}{\overset{\|}{C}}-H$)—This product, obtained via aldol condensation of acetaldehyde, is converted almost entirely to n-butanol and butyraldehyde. In addition, it finds limited application as warning agent in fuel gases and as raw material for the drug butyl chloral hydrate.

Consumption by the two primary derivatives, n-butanol and butyraldehyde, is considerable. Most of the alcohol's production (155 million lbs. in 1953) is obtained from crotonaldehyde. Competitively, n-butanol may be obtained by fermentation and, via butyraldehyde, by the Oxo reaction.

n-Butanol itself is a useful solvent for urea-formaldehyde resins, for ethyl cellulose, and for alkyds. It serves as raw material in the production of di-n-butyl phthalate, an important plasticizer.

Butyl acetate, produced by the esterification of acetic acid with 1-butanol, is considered the best medium-boiling solvent for nitrocellulose. In this function it finds wide-spread application in nitro-cellulose lacquer.

Butylamines, formed by the reaction of butanol with ammonia or various primary amines, are important intermediates in the production of resins and of a variety of flotation agents for use in the nonferrous mining industries.

The second most important derivative of crotonaldehyde, obtained by

mild hydrogenation, is butyraldehyde.

(f) **n-Butyraldehyde** (CH_3CH_2 CH_2C(=O)H)—This compound finds important utilization as intermediate in the production of butyric acid and its anhydride. The necessary conversion is carried out by a fairly simple air oxidation step in the presence of manganese salts which serve as catalyst. Butyric acid and anhydride are used extensively in the manufacture of cellulose butyrate and of mixed esters such as cellulose acetate butyrate. This group of chemicals is of significance in the manufacture of lacquers and plastics for molding purposes. Another important line of butyric acid derivatives are simple esters which serve as flavoring agents.

One of the most significant reactions of butyraldehyde is with polyvinyl alcohol to form polyvinyl butyral. PVB is used extensively as an interlayer for safety glass as well as for coating fabrics and in lacquer formulations.

Butyraldehyde can be condensed with aniline or other amines such as monobutylamine to form a prominent series of rubber accelerators. Condensation of butyraldehyde with phenol will yield an important class of oil-soluble resins. The self-condensation of two molecules of butyraldehyde and subsequent conversion to ethyl hexyl alcohol has assumed significance. The derivative alcohol is esterified to yield trioctyl phosphate or dioctyl phthalate, both of which are outstanding plasticizers for polyvinyl chloride and cellulose acetate resins. Another valuable plasticizer is derived from diethyl acetic acetate, produced via aldol condensation of butyraldehyde with acetaldehyde.

(g) **Higher Aldehydes**—Isovaleraldehyde ($C_5H_{10}O$), obtainable by the Oxo reaction with isobutylene or by dehydrogenation of isoamyl alcohol is a valuable ingredient in ethereal oils. Production is relatively small. Neither it nor its C_6- and C_7-homologues are derived from petrochemical sources at the present time.

Octyl and nonyl aldehydes, produced by the Oxo reaction with C_7- or C_8-olefins play an important part as intermediates in the production of octanol and nonanol. (Note that one isomeric octanol is also manufactured from butyraldehyde as outlined above.) These alcohols are esterified with phthalic acid anhydride or, to a lesser extent, with phosphorus oxychloride to yield plasticizers of outstanding usefulness in the forming of vinyl and cellulosic resins and of Buna N-type rubbers. U. S. production of dioctyl phthalate alone was 86.9 million pounds in 1952.

In this application, the aldehydes play only an indirect role. For reasons which will become apparent later in the discussion of the Oxo process, isolation of the aldehydes is not feasible prior to hydrogenation of the crude reaction mixture. To cover the limited demand for the C_8- and C_9-aldehydes as such, the corresponding alcohols are purified and dehydrogenated.

Some mention should be made in this connection of glyoxal—$(CHO)_2$—a dialdehyde produced by the partial oxidation of ethylene glycol. This compound finds its major application in shrink-proofing rayon. Other, more limited uses include insolubilizing of polyhydroxy materials such as polyvinyl alcohol. Annual glyoxal production, all by one manufacturer, is estimated at about 1,500,000 pounds.[17]

Methods for Aldehyde Production—Eight methods of synthesis serve for the commercial production of aldehydes. They are of varying degree of applicability to different members of the homologous series. The processes may thus be classified within three major categories which are defined by scope of usefulness.

(A) Processes for the Specific Production of Numerous Aldehydes
1. Conversion of Alcohols by Oxidation and Dehydrogenation
2. The Oxo Synthesis
3. Aldol Condensation and Conversion

(B) Processes for the Non-Specific Production of Several Aldehydes
1. Oxidation of Hydrocarbons. (Note: One version of this process yields formaldehyde almost exclusively)
2. Fischer-Tropsch Synthesis (Iron Catalyst only)

(C) Processes for the Specific Production of a Single Aldehyde
1. Hydration of Acetylene (Acetaldehyde only)
2. Decomposition of Ethers (This process, used today only for acetaldehyde production, has also served for acrolein manufacture)
3. Decomposition of Ethylidene Diacetate (Acetaldehyde as By-Product of Acetic Anhydride Manufacture)

As may be seen from this outline, there is some overlapping between categories. The exceptions are, however, of such limited industrial importance, that the broad scheme may be held valid.

It is within this framework that technical aspects of the different available methods for industrial production of the aliphatic aldehydes shall be considered.

Route No. 1

Conversion of Alcohols—Of the eight commercial routes to aliphatic aldehydes, only one—the oxidation or dehydrogenation of primary alcohols—finds application for the entire homologous series. On a volume basis it is also the leading method for the production of aldehydes. The principles and practice in this method of synthesis are best illustrated by reference to the production of formaldehyde and acetaldehyde from their respective alcohols.

(1) **Formaldehyde**—Methanol may be converted to formaldehyde by air oxidation or catalytic dehydrogenation. In this instance special considerations are raised by the occurrence of a secondary reaction causing breakdown of the desired product to carbon monoxide and hydrogen.

Dehydrogenation:

$$CH_3OH \rightarrow HCHO + H_2 \qquad \Delta H_{298^\circ C} = 21 \text{ Kcal} \quad (1)$$

$$HCHO \rightarrow CO + H_2 \qquad \Delta H_{25} = 2 \text{ Kcal} \quad (2)$$

Oxidation:

$$\tfrac{1}{2}\,O_2 + CH_3OH \rightarrow HCHO + H_2O \qquad \Delta H_{25} = -37 \text{ Kcal} \quad (3)$$

$$\tfrac{1}{2}\,O_2 + HCHO \rightarrow CO + H_2O \qquad \Delta H_{25} = -56 \text{ Kcal} \quad (4)$$

$$\tfrac{1}{2}\,O_2 + CO \rightarrow CO_2 \qquad \Delta H_{25} = -68 \text{ Kcal} \quad (5)$$

The objective of conversion must be to achieve formaldehyde production at conditions which are least favorable for the decomposition of the product by Reaction (2) or (4)

It has been shown[3] that straight dehydrogenation cannot be carried out at conditions which permit isolation of formaldehyde in significant yield. Practical execution of methanol conversion to formaldehyde is therefore confined to two approaches: (a) straight oxidation, and (b) combination of oxidation and dehydrogenation in a thermally balanced system. Both methods of synthesis are employed on a commercial scale.

All of the reactions outlined above

occur to a progressively greater degree as the temperature is raised. The objectionable formaldehyde decomposition (equations 2 and 4) proceeds at an appreciable rate above 300 C. For this reason, reaction conditions which form formaldehyde not far above this temperature will lead to optimum yield. This is the approach employed in straight oxidation.

The reaction equilibrium of methanol oxidation, (equation 3), is favorable even at low temperatures (by contrast, straight dehydrogenation cannot be effectively carried out below 500 C.). One must therefore employ a suitable catalyst which will promote oxidation as a heterogeneous reaction while formaldehyde decomposition remains homogeneous and its rate therefore unaffected. Such a catalyst is iron-promoted molybdenum oxide. A straight oxidation process based on this precept serves for at least a part of DuPont's formaldehyde production.[4]

Stoichiometric requirements call for a reactor feed gas containing 28.5 percent methanol in air. Such a feed composition is, however, within the explosive range at elevated temperatures. The explosive range of methanol in air has a lower limit of 7.5 percent at 50 C., 5.9 percent at 250 C. Its upper limit is reported at 24.9 percent at 100 C. and 36.8 percent at 200 C. and may therefore not be used in practice.[5]

A second limitation on initial methanol concentration is set by aspects of thermal balance. The system is to be held below the level of excessive formaldehyde decomposition, without resort to external cooling. The exothermic heat of reaction must therefore be absorbed by the sensible heat of the system.

The upper limit to permissible temperature is set by the extent of formaldehyde decomposition. As we have noted, this becomes significant for pure formaldehyde above 300 C. However, at this level, the reaction occurs quite slowly. Furthermore, its progress is repressed by the presence of diluent (i.e. air in this instance). It therefore becomes quite feasible to permit upper temperatures as high as 400 C., and possibly even 450 C. In an adiabatic system, 400 C. is reached by partial oxidation of methanol at an initial content of 8 percent. A starting mixture of 5.5 percent will result in a converter exit temperature of 300 C. This, then, defines the range of methanol-in-air concentrations which may be feasibly employed for synthesis of formaldehyde by straight oxidation.

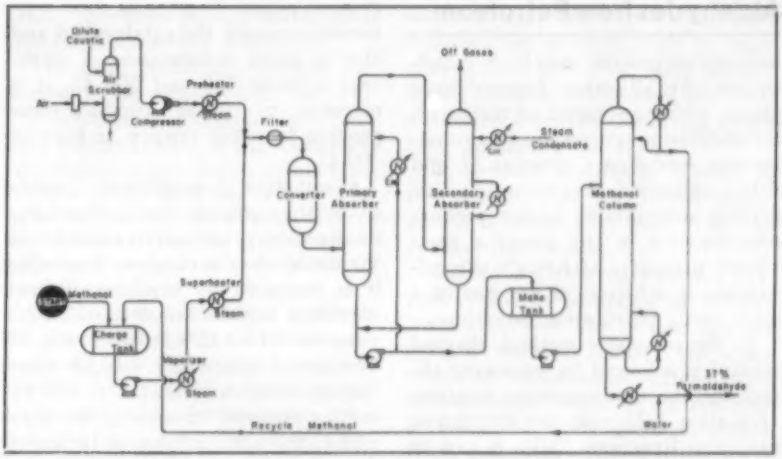

Figure 3. Simplified flowsheet of the combined oxidation-dehydrogenation process for production of formaldehyde from methanol.

Effect of operating variables in this process has been determined by Adkins and Peterson.[6] The preferred catalyst, containing iron and molybdenum in equimolecular proportions, was prepared by the addition of aqueous ammonium molybdate to a ferrous malate solution. Excess ammonia was added and the solution was evaporated to dryness in the presence of steel balls which act as carrier.

Feed gas concentration ranged from 6.2 to 7.1 volume percent methanol, i.e., well below the explosive limit at the point of entry into the catalyst. Maximum operating temperature was 400 C.

The activity of the catalyst increased during the early stages of its use until conversion reached a value slightly above 90 percent (average 90.8 percent). Activity at this peak efficiency could be maintained for months without change in conditions.

At a space velocity of approximately 0.15 sec^{-1}, formaldehyde yield attained its maximum value of 90.7 percent at 373 C. This compares with 90.0 percent at 353 C. and 85.3 percent at 400 C. Per-pass conversion rose from 85.2 percent at 353 C. to 91.8 percent at 373 C., which thus appeared to be the optimum temperature at the conditions chosen.

At any one temperature, maximum conversion is governed by contact time. Above its optimum value, decomposition reactions take an increasing toll of product, while formaldehyde formation cannot proceed adequately at too short a reaction time.

In a modification of the straight oxidation process,[7] the reaction is carried out in several successive stages. Between stages, the gas stream is cooled and an additional amount of methanol is injected into it. This method, which has gone through pilot-plant evaluation, permits greater build-up of product concentration and therefore reduces recovery costs. Here, too, a limit is set by the lower end of the explosive range for the methanol-formaldehyde mixture in air. Moreover, Adkins and Peterson[6] have noted that methanol oxidation in the presence of iron-molybdena catalyst requires very considerable excess oxygen.

Combined Oxidation-Dehydrogenation of Methanol—As we have seen, straight oxidation is characterized by very high formaldehyde yields and may be taken to nearly complete conversion of the feed methanol. This simplifies, of course, the purification problem greatly and results in efficient raw materials utilization. However, the process suffers economically from the low product concentrations to which it is confined. Feed methanol content may not exceed 5-8 percent and product concentration is in the same range. The results are high power cost for air compression, large cooling water requirements, and costly process equipment for product recovery.

Thus, in spite of its attractive aspects, the straight oxidation process has found commercial application in

only one or possibly two U. S. installations. At all other formaldehyde plants, which are based on methanol, the underlying process involves simultaneous oxidation (equation 3) and dehydrogenation (equation 1). This permits substantially higher product concentration in the reactor gases (30-40 percent), although this advantage is achieved at the cost of a more costly purification procedure.

In the composite method, thermal control is achieved by balancing the endothermic decomposition reactions (Equation 1-2) with the exothermic oxidation Reactions (3-5). A look at the heat values involved will immediately show that, at the balance point, nearly two-thirds of the formaldehyde formation will be obtained by dehydrogenation (at adiabatic conditions. Actually, oxidation plays a somewhat greater role).

Dehydrogenation does not proceed to an appreciable extent below 500 C., and conversion attains completeness only about 750 C. At thermal balance, this upper temperature is reached from an initial methanol concentration of 37 percent at 110 C., i.e. a mixture barely above the explosive limit.

Actual range chosen for commercial operation is 600-660 C. Catalyst temperature governs the product composition since near-equilibrium for Reactions (1) and (3) is attained. The peak temperature may be adjusted downward either by raising initial methanol content or by admixture of steam. To reach 630 C. in an adiabatic system starting at 110 C., the initial mixture should contain 39.2 percent methanol in air.[8] Theoretical product composition, discounting disintegration reactions, contains 30.8 percent formaldehyde and 11.6 percent hydrogen. Most of the balance is nitrogen and steam.

This picture is modified by the simultaneous occurrence of decomposition reactions which lead to carbon monoxide formation. To repress their progress, temperature should be held to the lowest feasible value, and contact time must be minimized, even to the extent of taking incomplete methanol conversion per pass. The catalysts chosen for formaldehyde synthesis are highly specific and do not promote the breakdown of formaldehyde which occurs in homogeneous phase. To prevent their continuance outside the catalyst bed and also to avoid re-formation of methanol between 350 and 500 C., it is necessary to "freeze" product composition by rapid cooling at least to 300 C.

Commercial formaldehyde synthesis by the composite oxidation-dehydrogenation process rests entirely on the use of silver as catalyst. Typically, it is prepared by crushing electrodeposited metallic silver into coarse granules (.15-1.25 mm diameter).[8,9] The metal grains are washed thoroughly, dried, and heated to 650 C. in the presence of air. In the converter, the sized catalyst is arranged in a stratified bed, with the smallest crystals at the top since gas flow is in downward direction. A copper screen serves as catalyst support.

For reasons outlined above, contact time must be held at a minimum. With the highly efficient silver catalysts available for formaldehyde synthesis, bed depths of only 10 mm may be used, and favorable results are also obtained with silver gauze. Initial catalyst temperature is held at 600 C. by suitable adjustment of the feed rate. As catalyst activity declines, the temperature must be raised gradually to 650-660 C.

This is the feasible operating limit set by considerations of yield. Once this level has been reached, a fresh batch of catalyst must be charged. In all, the active life of electrodeposited silver in this service ranges between six and twelve months.

The converter itself is a vertical cylindrical vessel, guarded by flame arresters at the inlet and outlet ends. One approach, adopted by Spencer Chemical Company[4] is the use of multiple reactors of small size in order to minimize production loss from breakdown in one unit. A single set of flame arresters may serve for a whole bank of reactors (at Spencer's Calumet City plant, 25 parallel contactors are coupled into a single system).

Durez, using fairly large reactors,[13] has joined three parallel units into each bank, Converters at Leverkusen[9] are three feet in diameter, each with a daily capacity of 10,000-12,000 pounds formaldehyde (dry basis).

Iron is a virulent catalyst poison, and high chrome-nickel stainless steels (or copper) must therefore be employed for reactor construction and for all equipment upstream of the converters. This, and other poisons must also be rigorously excluded from the feed materials. The stringent specifications set by formaldehyde synthesis are now generally met by commercially available methanol.

Incoming reaction *air* is filtered, freed of contained sulfur compounds by scrubbing with dilute caustic, and finally cleaned in an entrainment separator. Air temperature is raised to 50-70 C. en route to its juncture with methanol.

Feed methanol is vaporized and joined with air in a special mixer which minimizes residence in the explosive range. Methanol content of the mixture is between 40 and 50 volume percent.

The methanol-air mixture is passed through a final filter to assure absence of any entrained material which might be deleterious to the catalyst. It then enters the top of the converter.

Operating temperature, set by catalyst age and activity, is between 600 and 660 C. It is controlled within some 3 C. of the desired level by adjustment of the reactants' ratio. In the course of passage through the catalyst, 55-60 percent conversion is taken. Reactor yield is variously reported between 87 and 92 percent. Small additional losses occur in the course of product recovery and purification.

The hot gases issuing from the bottom of the catalyst bed must be immediately cooled to 200-250 C. to prevent reversion to methanol, and losses from formaldehyde degradation and formation of methylal (from methanol plus formaldehyde). This shock-cooling may be accomplished by locating the reactors close to the primary product absorption towers, which latter units thus also serve for quenching purposes.[13,14] Alternately, tubes may be provided in the lower part of the reactor to achieve temperature reduction below the critical level by indirect heat exchange.[8,9]

The emergent gases pass to a primary scrubbing column which serves at the same time for gas cooling and for the absorption of contained formaldehyde, unconverted methanol, and other water-soluble components. These materials are allowed to build up to 28-30 percent formalin concentration in the circulating aqueous phase (F-M liquor) which serves as absorber liquor. The liquor, with-

drawn from the bottom of the column, is continually returned to a plate near the absorber top via an external cooler. A portion is withdrawn and forwarded to the formaldehyde finishing column.

To insure practically complete removal of organic components from the waste gases, they are contacted by a water spray at the top of the absorber above the F-M liquor feed point. In most plants, a secondary absorber column (also of the recirculating type) serves for final depletion of the spent gases. Its liquor concentrate serves as part of the feed to the primary column.

As indicated above, a portion of F-M liquor is continually withdrawn from the primary absorber's recirculating stream. This is forwarded to a standard distillation column in which 99 percent methanol is taken overhead. The bottoms are normally controlled to contain 37 percent formaldehyde and less than 1 percent methanol.

In a variation of this formaldehyde process, almost complete conversion of methanol may be taken in a single pass. The gases are scrubbed with recirculating aqueous formaldehyde solution followed by a water wash in the manner outlined above. In this case the problem of methanol recovery does not exist. At the same time the primary scrubber liquor is already a sufficiently pure formaldehyde solution (30-37 percent) to satisfy many commercial requirements so that a distillation step is made unnecessary. Some methanol is unavoidably present, and its content ranges from 0.5-3.0 percent. In this single-pass version of the process, the greater simplicity of the purification system is paid for, above all by poorer raw materials utilization. Yield is 82-84 percent, compared with 87-90 percent in the recycle process (55-60 percent conversion per pass) which has been outlined above.

(2) **Acetaldehyde from Ethanol**—Unlike formaldehyde, acetaldehyde may be produced by straight dehydrogenation. In this instance, the tendency to product deterioration is not as pronounced and the dehydrogenation equilibrium is favorable at lower temperatures than is the case in methanol conversion.

Combined oxidation-dehydrogenation, which does not require heat transfer to and from the reaction phase, also finds commercial application for acetaldehyde production.

The third possibility, straight oxidation, is not employed in this field. The conditions of product instability and unfavorable dehydrogenation equilibrium which make oxidation attractive in the synthesis of formaldehyde despite the drawbacks of very high product dilution, are not markedly encountered in acetaldehyde production.

Of the two commercial methods for conversion of ethanol to acetaldehyde, the dehydrogenation process is favored.[11,12] Its chief advantages rest on greater ease of temperature control, the formation of by-product hydrogen, less product dilution, and simpler purification (due to much lower water concentration in the product). This route to acetaldehyde has been practiced in the United States since 1930. Underlying is Reaction (6).

Dehydrogenation:

$$CH_3CH_2OH \rightarrow CH_3C(=O)H + H_2 \qquad (6)$$

Copper is a highly specific catalyst for this reaction. By itself, however, it loses its activity readily, a tendency which may be overcome by incorporation of suitable promoters.

A feasible dehydrogenation process, due to Church and Joshi[13] is based on the catalytic use of supported copper containing 5 percent cobalt and 2 percent chromium. Asbestos serves as preferred carrier. Upon loss of activity, this catalyst may be regenerated to initial effectiveness by air oxidation (400 C.) followed by reduction by alcohol at 280 C.

The endothermic reaction (600 Btu per pound alcohol converted) requires a constant supply of heat. The catalyst is therefore mounted in a tubular converter in indirect exchange with Dowtherm or similar medium.

Vaporized, preheated 95 percent ethanol enters the catalyst bed which is maintained at 275-280 C. At this temperature and with a 90 percent per-pass conversion of alcohol, acetaldehyde is formed in 85 percent yield. Ten per cent of the charge alcohol is usefully converted to by-product ethyl acetate and 5 percent is lost to diverse side reactions.

Church describes product recovery by sub-cooling the make gases to —10 C., but other means (e.g. absorption) may also be used. Standard fractionation methods serve to separate acetaldehyde from ethyl acetate, water, unconverted ethanol, and other associated materials (including scrubbing medium, if any).

By-product hydrogen, formed in this process, is of 98 percent purity, and is a serviceable feed to hydrogenation operations.

Oxidation-Dehydrogenation of Ethanol—Straight oxidation of ethanol is not practiced. The method actually selected parallels closely the composite air oxidation-dehydrogenation method which serves in the synthesis of formaldehyde from methanol. Here, too, silver catalyst is employed.

Work by Faith and Keyes[14] indicates that the unsupported metal, largely because of its high heat conductivity, leads to particularly good yields. Per-pass acetaldehyde yield over silver gauze showed a pronounced maximum of 80.6 percent at 515 C. Actual per-pass conversion is, however, held below this value in order to minimize over-oxidation.

According to Shreve,[15] the reaction is carried out commercially at 550-570 C. with a per-pass conversion of 50-55 percent and a yield of 85-95 percent (this upper yield limit appears excessive and should probably be closer to 90 percent). Using a feed ratio of 1 mole ethanol: 0.3 moles air (i.e., a 40 percent initial alcohol concentration), Hsü[16] obtained acetaldehyde in 90 percent yield over silver catalyst at 460 C.

Design considerations in the composite process for acetaldehyde production are along the lines discussed above in connection with formaldehyde synthesis. ##

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End of Part 1. Part 2 will appear in an early issue.

Fractionation Research Starts Era

Forty-three companies cooperate in new phase of research program to find the effects of tray design, system properties, and operating conditions on capacity and tray design efficiency.

REPRESENTATIVES of 43 companies prominent in the chemical and petroleum industry met in Los Angeles recently to plan the next phase of a joint research-program that will benefit processors and users of chemical and petroleum products. The cooperating companies are stockholder-members of Fractionation Research Incorporated, a non-profit organization formed to study the performance of fractionating-equipment. During the session, members of the FRI committees inspected a new experimental distillation plant in which many of the studies will be made. C. F. Braun & Co. designed and constructed the test-unit, just completed adjacent to their own research center in Alhambra, Calif. The Braun firm, itself a member of FRI, will provide the engineering and operating staff for the program.

The objective of FRI is to determine the effects of tray-design, system properties, and operating conditions, on capacity and tray efficiency. Basic information will be developed, leading to two things. (1) Revamp of existing equipment for increased capacity, or better separating efficiency. And (2) design of new columns that are less costly, more flexible, reliable, and effective than those designed with existing knowledge.

While several companies have made attempts to obtain the data necessary to predict such things as vapor-liquid handling capacity and separating efficiency under various loading conditions, the cost of a complete research program is too high for an individual company to justify. By pooling their resources, the FRI member-companies hope to accomplish what one alone could not afford to do. T. B. Hudson is president of FRI and chairman of the Executive Committee, and 43 chemical, petroleum, and engineering companies have joined in the research effort. Fractionation Research is not a closed corporation. Membership is open to any company that wishes to participate.

For a new era in fractionation, a three-tray simulator column.

The FRI research program will involve three principal phases. They are (1) investigation of various distillation devices, by means of a so-called simulator column. (2) More exhaustive study in the new experimental distillation unit of those devices that show promise in simulator test. And (3) full-scale tests in actual plants to check and extend the experimental data. The program is under the supervision of FRI Technical Director Francis W. Winn.

The 66-inch, three-tray simulator column, privately built sometime ago to study experimental tray-designs, will be used as a screening device for testing bubblecap-trays and other contacting devices. Those that look most promising will then be studied in the 48-inch, ten-tray distillation column. The first studies will be on bubblecap trays, because of their present widespread use.

Reliable information about the capabilities of a properly designed bubblecap tray, can be used as a standard against which to judge the performance of other trays, such as perforated plates and proprietary devices.

Binary systems will be used at first to test tray-designs. Two such systems now in use are mixtures of n-butane with isobutane, and cyclohexane with normal heptane. Other systems which may be used are isopropyl alcohol with water, methyl ethyl ketone with secondary butyl alcohol, and hexane with absorption-oil. Most of the work will be with binary systems because analysis is simple and reliable, but sufficient studies will be made with multicomponent mixtures to be sure that the results of binary tests will apply to complex systems. ##

Figure 1. Electronic vs. Pneumatic Controllers.

Test installation of electronic controller. Test installation of pneumatic controller.

Why Electronic Process Control?

The answer lies not in its speed but in the increased reliability in cold climates, flexibility and better control.

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THE HISTORY of process control is one of constant change. At the beginning, plants were controlled by hand from a few thermometers and pressure gages. At first these instruments were located at the point of control and later the controllers were developed to control the process variables automatically. Eventually, pneumatic controllers were located in centralized control rooms,with pneumatic transmission to and from the point of measurement and control.

However, as units became more complicated the number of instruments increased until panel boards were so long that it became difficult to get an over-all perspective of the operation of the plant. At the same time the physical size of the plants increased making transmission distances longer.

Trend to Graphic Panel—In the late 1940's the trend towards the graphic panel type of instrumentation developed. The prime reason for going to this type of instrumentation was to reduce the size of the control boards to make them more easily comprehensible. This necessitated the development of a new type of instrument which occupied less panel space. Coincident was the development of unitized construction of controller components to give the required flexibility of controller mounting. Controllers of this type, due to their force balanced designs, were found to have better performance characteristics. They had less dead-band and generally had higher capacity air pilots, so that they could move the control valve faster.

The graphic panel type of instruments, due to their unitized construction, are more flexible in their application and can be used with the controller mounted directly on the control valve to eliminate the transmission lag. The importance of this transmission lag should not be underestimated since a long lag can give a flow controller a period of oscillation approaching that of a temperature controller. In that case an upset in a flow controller would in turn disturb one of the major temperature controllers in a plant, setting up a cycle before the flow controller could dampen out the swing.

Unfortunately, industry as a whole has not taken full advantage of the graphic panel type of instruments insofar as improved control is concerned, even though a fair percentage of the new large process control installations are going in with the process picture feature of this graphic panel.

New Electronic Controllers—Even though industry, as a whole, is not now taking full advantage of the improved control available, a new form of process control is being considered by some engineers. With this system the measurement of the process variables, the transmission, and the controlling is done electrically. The final control element, the valve, still is positioned by means of compressed air.

Electronics is a magic word in the minds of most people and conjures up visions of being able to do, electronically, most anything at the speed of light. However, it is always interesting to run comparisons before deciding which system is better.

The biggest contribution to the field of automatic control in recent years has been the adoption of the frequency response techniques of the servo-mechanism field to the process control industry. While the relative merits of frequency response and step responses techniques can be argued back and forth, the important fact to remember is that frequency response has given the process industry a means of communication. It is now possible to compare intelligently the relative merit of one control system over another on a quantitative basis.

In order to evaluate the performance of electronic controllers in comparison to the pneumatic controllers in use today, frequency response runs

Figure 2. Control house at Rock Island's platformer: Virtual absence of tubing at corner.

were made on two of each which were available on the present market.

Frequency Response Tests—The tests were run by loading a pneumatic sine wave into the flow transmitter and recording the output pressure of the controller at a 10-inch diaphragm top-works as shown in Figure 1. In this manner a performance picture was obtained of the whole control system from the measurement by the transmitter to the actual pressure change in the diaphragm motor top-works.

Figure 3 shows the comparison of the frequency response of the two electronic controllers and the two pneumatic controllers. The pneumatic controllers were each checked with and without the effect of 100 feet of ¼-inch transmission line to and from the field.

It can be seen from the phase shifts and magnitude ratios, that while the performance of the electronic controllers is not as good as that of the valve mounted pneumatic controllers, it is better than the performance of the pneumatic controllers mounted on a control board 100 feet away.

This proves to be a rude awakening from our visions of high speed performance from an electronic controller. The fact is that although the transmission and control is almost instantaneous there still remains the valve to be moved pneumatically and the air pilots supplied with the electronic controllers did not quite have the air handling capacity of some of the pneumatic controllers. This shows up when the controllers are mounted directly on the diaphragm top. The introduction of only 6 feet of ¼-inch copper tubing as in Figure 5, will bring the performance of the pneumatic controller down to that of the electronic controllers. If one element in the control system is slow, it slows the whole system.

It is interesting to note that, while the addition of an amplifying relay or valve positioner to a control system with the controller 100 feet from the valve will help the magnitude ratio, (see Figure 6) it presents some rather serious difficulties as far as phase shift is concerned. Thus, while a pneumatic controller mounted on a board 100 feet away from the valve could be made to move the valve with as great a magnitude ratio as an electronic controller, or a valve mounted pneumatic controller, it would have a serious phase shift or stability problem.

Therefore, we are presented with the performance picture of the new electronic controllers. The controllers are not quite as fast as properly installed pneumatic controllers but are faster than the usual installation of

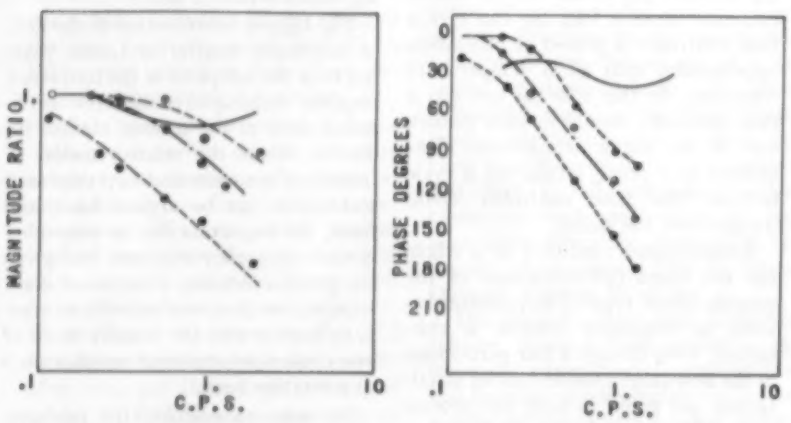


Figure 3. Relative frequency response curves—electronic controllers versus valve mounted pneumatic controllers and pneumatic controllers with 100 feet of tubing between controller and valve. Legend: ——— Pneumatic controller mounted on valve; — - — - — Electronic Control A; — — — — Electronic Control B; - - - - - -100 feet of transmission to and from controller.

pneumatic controllers. The question is whether industry is ready to change to electronics. If speed were the only consideration the answer would probably be no.

Problems Presented by Use of Air—Automatic control in the northern climates, however, has always been under a serious handicap due to the problem of handling instrument air at low temperatures. At the present time, there is quite a growth in the northern process industries and this should warrant serious consideration of an electronic system of measurement and control, if for no other reason than increased dependability under severe conditions of cold.

Considerable trouble was experienced in the early operation of this unit due to troubles with the instrument air dryer. Inasmuch as the measurement of all of the process variables except temperature, required air, even a small amount of wet instrument air would leave the operators blind as far as knowing what the conditions were in the unit.

The present electronic instruments promise an improvement in that they would at least continue to give a measurement under these conditions. It is, however, unfortunate that they still require air to move a control valve.

Actually, air is a very poor medium for operating a valve. It is very expensive. An instrument air system for a plant with 80 controllers could easily cost $15,000. Air, of course, is compressible and this presents serious problems sometimes when there is a dynamic unbalance existing across the control valve, as many engineers can testify. Air diaphragm motors have always presented a problem to designers of diaphragm control valves due to their short stroke and instability under severe valve unbalance. The main reason that air is so popular is the ease with which the control functions can be obtained. However, with an electronic controller this is no longer a factor.

Another problem that is inherent with an air system is the positioning of the valve with air failure. Most of the time it would be best for the valve to remain in one spot upon air failure. This is very difficult to do with a diaphragm motor valve.

Alternate Means for Valve Actuation—An electric motor geared to the valve shaft would not be a practical solution to the problem. A motor and gears with enough power and speed that would compare with present pneumatic valves would be too costly an installation to consider. Besides the question of cost is the fact that the normal process control valve spends 90 percent of its life in one position moving only very slightly either way from this point. This means that there

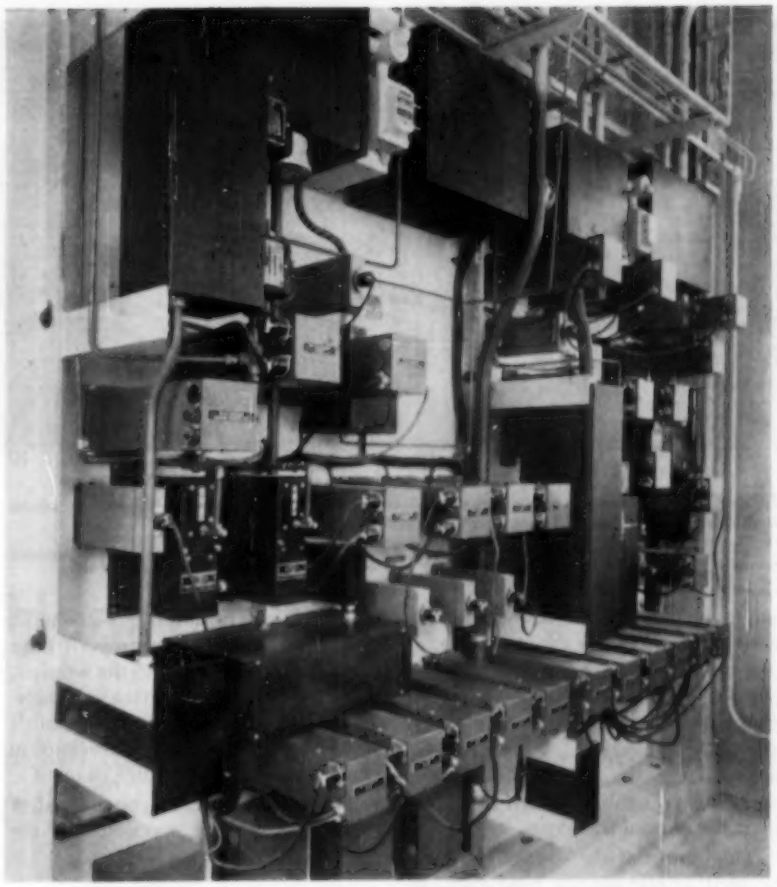


Figure 4. Back of control panel at Rock Island's platformer: Each unit is plugged into its own housing.

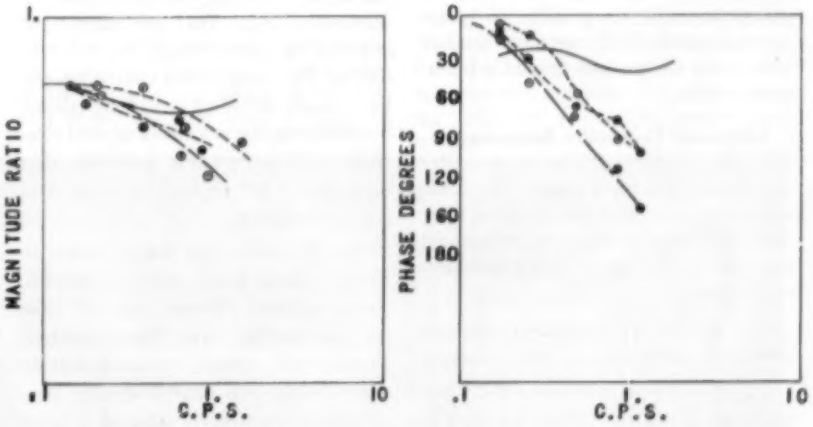


Figure 5. Relative frequency response curves—electronic controllers versus valve mounted pneumatic controllers and pneumatic controllers with 6 feet of tubing between controller and valve. Legend: ——— Pneumatic controller mounted on valve; — - — - — Electronic control A; — — — — Electronic Control B; - - - - - - 6 feet of ¼" tubing from controller to valve.

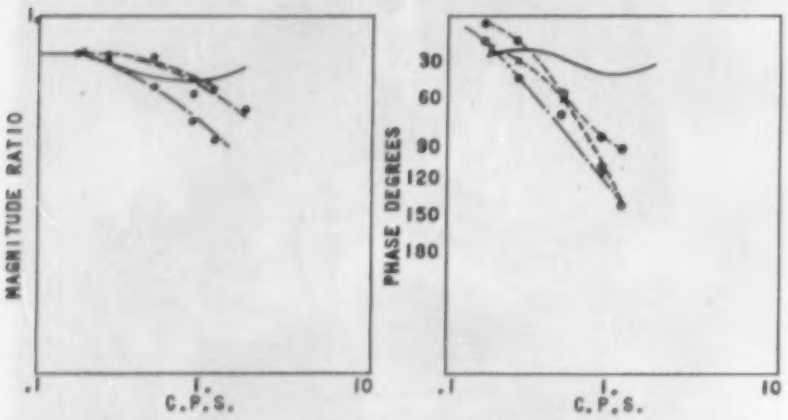


Figure 6. Relative frequency response curves—electronic controllers versus valve mounted pneumatic controller with 100 feet of tubing and pneumatic amplified at valve. Legend:

——— Pneumatic controller mounted on valve; — - — - — Electronic control A; — — — — Electronic control B; - - - - - - 100 foot transmission to and from controller with pneumatic amplifier at valve.

would be a terrific concentration of wear at one point on the gear train.

A more practical solution appears to be an electro-hydraulic approach. A relatively small motor and pump equipped with an accumulator can deliver a large amount of power for a short time, probably enough to handle most the normal transients.

The output of the controller would be used to operate the pilot valve in the hydraulic line. While such a system is capable of extremely high speed performance, it is doubtful if it would be necessary to consider any responses faster than 1 cps for a majority of process uses. For this reason a much simpler and consequently less expensive systems could be used.

In the event that an instrument air system could be eliminated from a plant, it would be possible to spend approximately $175 extra per control valve over the present cost of a pneumatic valve.

Electronic Controller Advantages—Once the problem of moving the valve electrically has been solved, electronic controllers should come into their own and will have several big advantages over the present pneumatic controllers as follows:

(1) Electronic controllers will give increased reliability in cold climates.

(2) Electronic controllers will eliminate the need for tubing racks. The major part of the installation cost of an instrument is in building the tubing rack. The cost of the tubing itself is only a fraction of the cost as compared to the rack if it is to be properly built to protect the tubing from the weather, corrosion, and mechanical damage. The tubing has to be continuously watched for leaks due to mechanical vibrations and temperature changes.

The electrical leads can be pulled through a conduit supported in the regular pipe rack.

(3) Electronic controls will give increased flexibility in some of the more complicated control problems. Much thought is being given to the possibility of using a computer to operate the processing plant. Actually, we are further along this path than most people realize. Where is the dividing line between a computer and normal process control techniques? We are cascading, limiting, and overriding controllers today that are capable of multiplying, integrating, or differentiating. The combustion control people have made use of electrical signals for interrelating the actions of several controllers. It is certainly probable that more of this will be done in the process control industry.

(4) Electronic controllers should be able to obtain better control. As mentioned earlier, "better control" does not necessarily mean faster control. Most of the critical control points on a processing unit have long time constants due to process lag and a faster action on the controller will not help the over-all control materially. Under these conditions, however, the deadband in the controller does become important, in that the greater the deadband the longer will be the time required for the controller to detect the initial error between the measured variable and the desired value.

(5) Electronic controls should have less noise. The problem of noise in process control systems has not had too much study; however, frequency response analysis of most of the critical process control problems shows that the controlling lag exists within the process itself. The derivative function in the controller can be used to move this lag towards a shorter period giving an improved over-all control. However, this requires some rather long time constant settings on the derivative unit. It is often found that full use can not be made of the derivative function because of noise that is present in the system, either in the process or the controller. With the electronic controller, it should be easier to make use of some of the servo-mechanism techniques of filtering out undersirable noise that is upsetting to the controller and thus obtaining more effective use of the derivative function.

One Unit Equipped With Electronic Controllers—A UOP Platforming unit recently was completed for Rock Island Refining Company at Indianapolis (Figures 2 and 4). This unit was equipped with electronic controls. The reasons for going to this type of installation were the first two given. Namely, more reliability under conditions of cold and the elimination of tubing racks. (Editor's note: See PETROLEUM REFINER, November, 1943.)

Inasmuch as the valves had to be pneumatically operated, because of the lack of a suitable electric operator, the electric pneumatic relays were specified with a small electric heater mounted on the pilot valve block to lessen the possibility of ice formation at this point.

The future of electronic controls appears very bright once the problem of operating the valve electrically has been solved. This actuator should be simple, inexpensive, and have a performance at least equal to a pneumatic diaphragm motor as far as speed and dead-band are concerned.

Original presentation was at the First International Congress and Exhibition of ISA, Philadelphia, September 15, 1954. ##

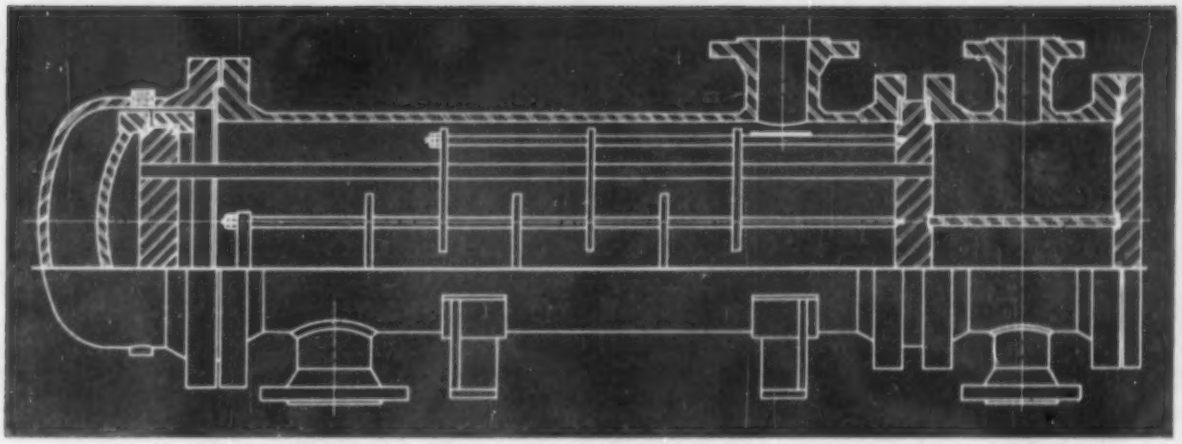


Figure 1. Floating head exchanger.

Economics of Heat Exchanger Design

Use of these curves will enable engineers to make rapid selection of the most economical exchanger for a specific purpose.

E. D. Anderson and E. W. Flaxbart,
Western Supply Company,
Tulsa

HEAT EXCHANGER selection is based largely on the experience of project and process engineers. Continuously changing labor and material costs, together with new chemical and petroleum processes, have hindered building up this necessary experience backlog. This paper presents curves which compare costs of various designs of shell and tube exchangers constructed of ferrous and non-ferrous alloys. These curves will aid the engineer in making a rapid selection of the most economical exchanger for a specific service.

Introduction—Shell and tube heat exchanger equipment usually constitutes from 5 to 15 percent of the total equipment cost of a new gasoline plant or refinery. The selection of the proper exchanger system is very important, for upon it depends the size of the fired heaters and cooling towers—items which demand continuing operating expense. The more heat transferred by process heat exchangers, the smaller the fired heaters and cooling towers. It is necessary for the process engineer to make this economic balance and specify what he thinks to be the most economical exchanger system. But the selection is not a simple one.

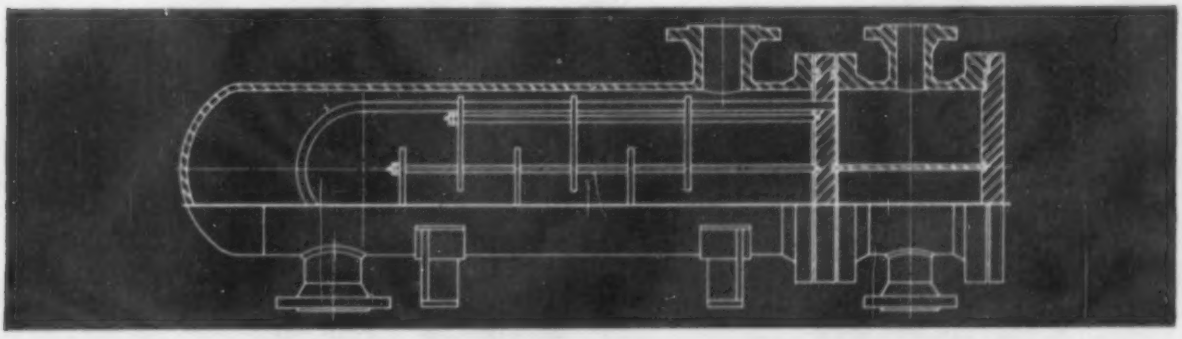


Figure 2. U-tube exchanger.

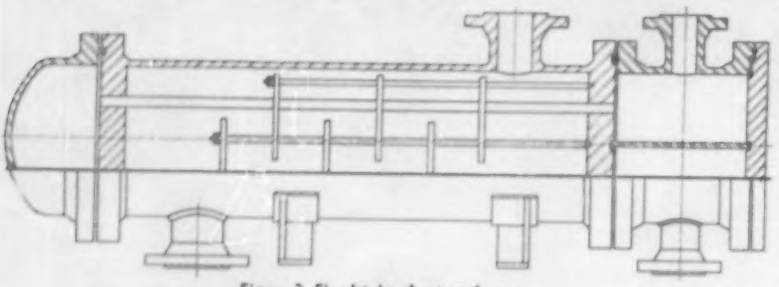


Figure 3. Fixed tube sheet exchanger.

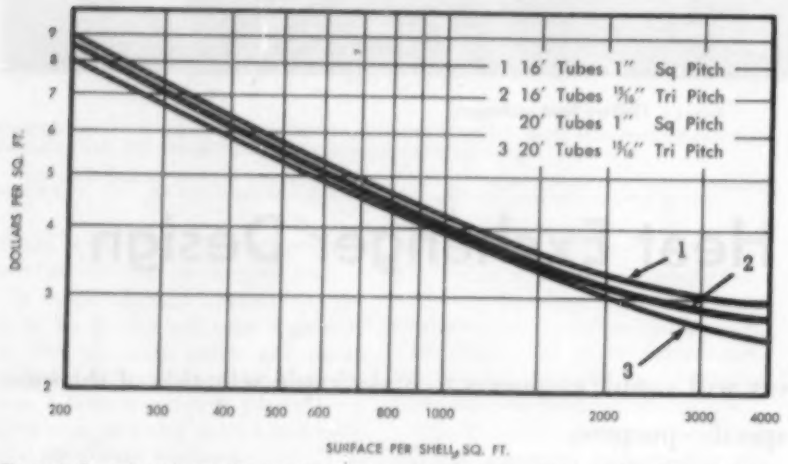


Figure 4. Costs for all steel floating head exchangers, ¾″ (od) x 14 Bwg tubes, 150 psi design pressure.

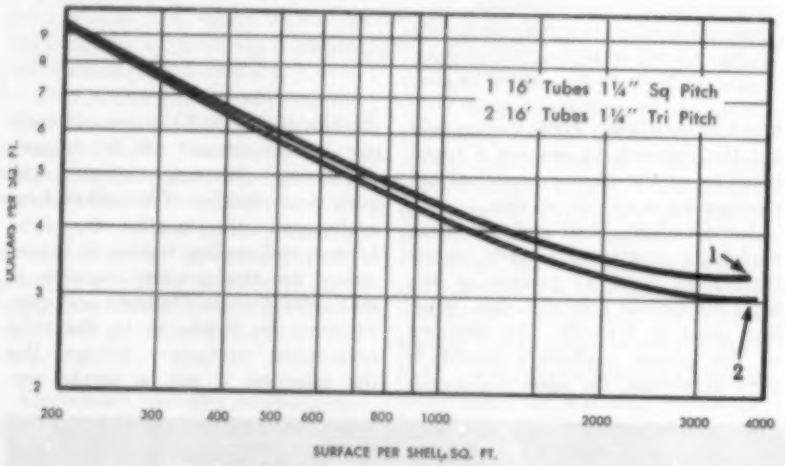


Figure 5. Costs for all steel floating head exchangers, 1″ (od) x 12 Bwg tubes, 150 psi design pressure.

Corrosion, products contamination, pumping costs and various other process considerations add to the complexity of the problem. The estimating curves presented here give cost comparisons between various types of shell and tube exchanger construction, thus facilitating the selection of the most economical exchanger system.

Construction Features—This discussion will be confined to various types of shell and tube heat exchangers for they are by far the most widely used of all types of exchange equipment. There are three basic types: the floating head, the U-tube, and the fixed tube sheet. As background for the cost curves, the following review of the features and variables of these exchanges is presented.

Experience has shown that ¾ and 1-inch od tubes are the preferable sizes. With these diameters, adequate velocity for good heat transfer without excessive pressure drop can usually be attained by proper selection of tube passes. The diameters are large enough to permit cleaning, and wall thicknesses of 12 to 16 Bwg provide sufficient metal for a wide range of pressures without excessive cost or weight. Tubes of these diameters and gages are considered stock items by most heat exchanger manufacturers and are readily available for exchanger retubing.

In the past, there were as many tube lengths as there were manufacturers and purchasers of heat exchange equipment. This led to extremely difficult stocking problems and was a disadvantage to users as well as exchanger manufacturers. Now, 16 and 20 foot tubes are considered standard. The 16-foot tube is used primarily in refineries where space is limited and, because of fouling, ease of bundle handling is necessary. In gasoline plants, where space is usually no problem, and the fluids are clean, 20-foot tubes are widely used. Because of the ease of handling, maximum shell diameters of around 36 inches are generally preferred in refineries, with larger diameters up, to 42 or 44 inches being used for gasoline plants. The size selection is based on handling equipment available in the plant. This may seem inconsistent, but, since in most gasoline plants, the fluids handled are noncorrosive and non-fouling, little maintenance is required.

For ordinary pressures, the tube gages usually used are 1-inch-12Bwg or ¾-inch-14Bwg for carbon steel and the low chrome alloys, and 1-inch-14Bwg or ¾-inch-16Bwg for Admiralty and the non-ferrous metals. Tubes of these gages are readily available from warehouse or manufacturers' stock.

Tube pitches are laid out on either a square or triangular configuration. Triangular pitch is used for clean and non-fouling shell side fluids. This tube pitch results in a higher transfer coefficient for a given pressure drop than square pitch. Square pitch is

used for fouling fluids where mechanical cleaning must be employed, or where a low pressure drop is required. With further development of chemical and allied cleaning processes, it will be possible to use more triangular pitched exchangers and gain the two-fold advantage of higher transfer rates and lower cost for given exchanger surface.

The Three Basic Types—The floating head exchanger, shown in Figure 1, makes provision for differential expansion between the tubes and shell by the tube sheet being fixed at one end only. Care must be taken by the designer in selecting the number of tube passes to be sure that the overall temperature drop of the tube side fluid is not sufficient to overstress the tubes in any pass. However, that is usually compensated for by the use of several exchanger shells in series or split floating head construction. The bundle of the floating head exchanger is readily removable to permit inspection and cleaning of the shell side. The tubes are straight and readily accessible for tube side cleaning. Should local corrosion or erosion occur, individual tubes can be easily replaced.

The U-tube exchanger, shown in Figure 2, is slightly lower in cost than the floating head and also provides for differential expansion between shell and bundle. The bundle is removable for cleaning the shell side of the unit. However, close radius U-bends do present a cleaning problem. The unit has no internal gasketed joint and can be used to advantage where the possibility of product contamination is a hazard. Individual tube replacement is not possible with the exception of the outside rows of tubes.

The fixed tube sheet exchanger, shown in Figure 3, is the lowest in cost because of its simplicity of design. As its name implies, the bundle is contained between two tube sheets which are fixed to the shell. The shell side is inaccessible for mechanical cleaning and, unless pressure drop is a consideration, the tubes are on triangular pitch. Usually, this type of exchanger is used where temperature difference between shell and tube fluids is small and no provision is made for differential expansion. It is possible to use expansion joints in the shells of these units to provide for differential expansion. Tube replacement in this exchanger is difficult, although individual tubes may be replaced. Because of its inherent low cost, this type of unit is widely used when expensive alloy construction is necessary, and on low profit margin plants where first cost is extremely important.

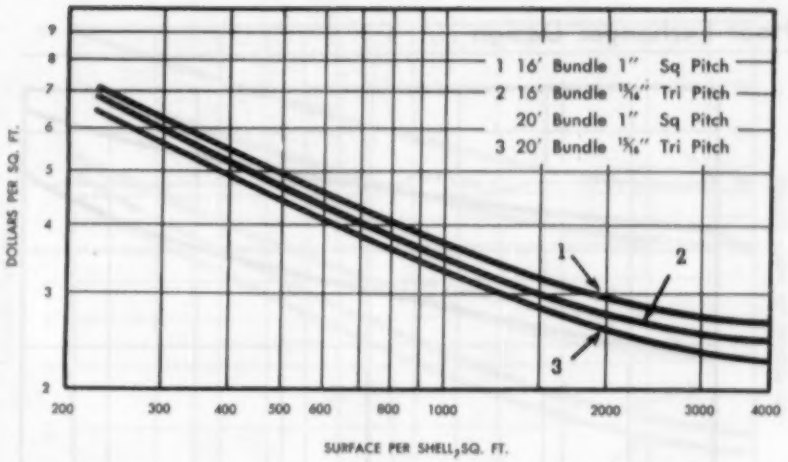

1 16′ Bundle 1″ Sq Pitch
2 16′ Bundle 15/16″ Tri Pitch
20′ Bundle 1″ Sq Pitch
3 20′ Bundle 15/16″ Tri Pitch
DOLLARS PER SQ. FT.
SURFACE PER SHELL, SQ. FT.

Figure 6. Costs for all steel U-tube exchangers, ¾″ (od) x 14 Bwg tubes, 150 psi design pressure.

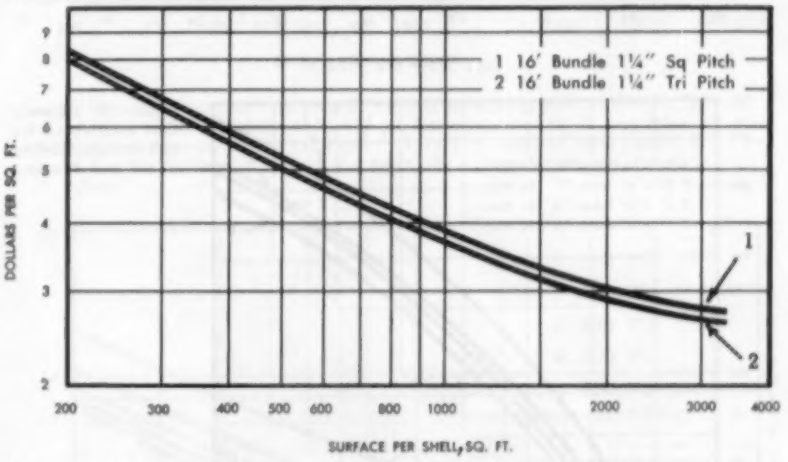


Figure 7. Costs for all steel U-tube exchangers, 1″ (od) x 12 Bwg tubes, 150 psi design pressure.

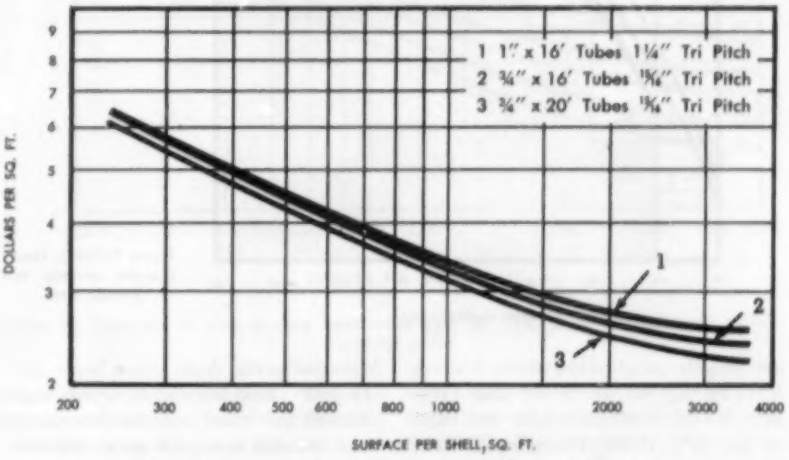


Figure 8. Costs for all steel fixed tube sheet exchangers, 1″ (od) x 12 Bwg and ¾″ (od) x 14 Bwg tubes, 150 psi design pressure.

Construction Codes—Exchangers

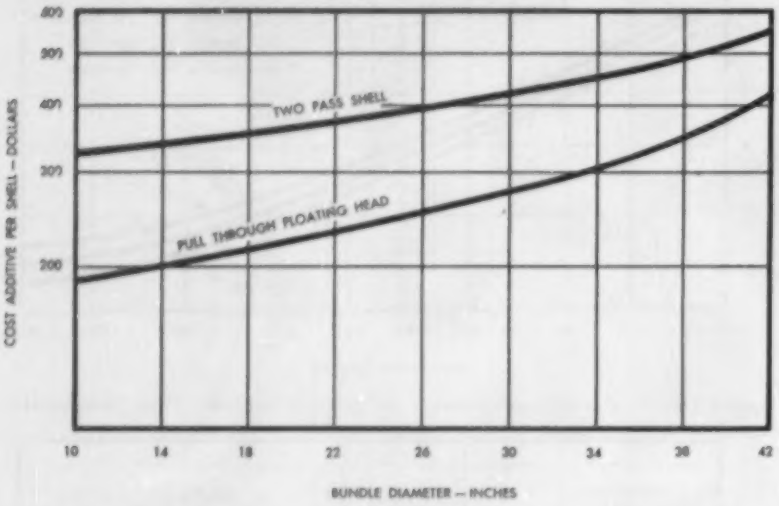


Figure 10 (above). Cost additives for pull-through floating head and two-pass shell.

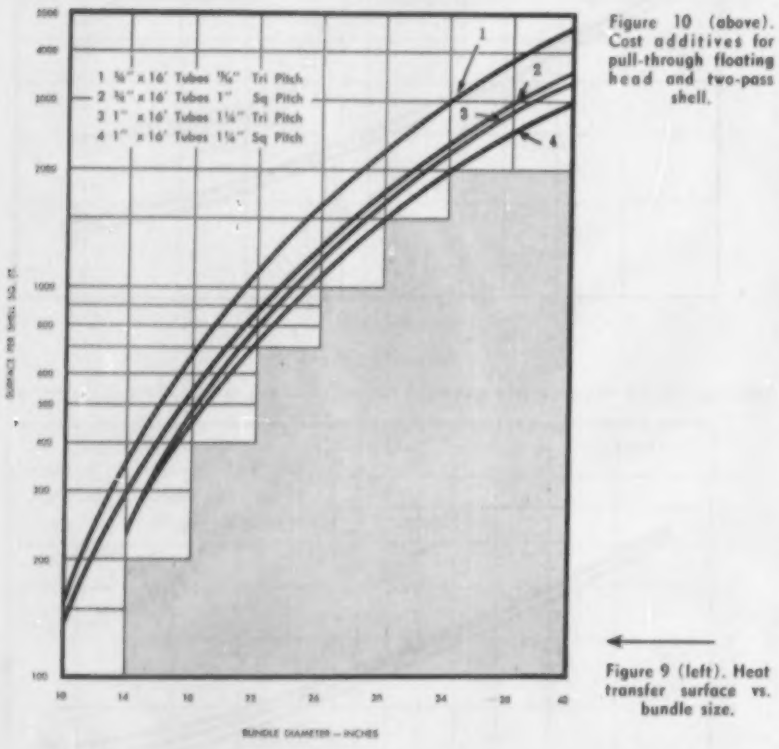


Figure 9 (left). Heat transfer surface vs. bundle size.

are usually constructed under Section VIII of the ASME Boiler and Pressure Vessel Code or under the rules of the API-ASME Code for Unfired Pressure Vessels. These codes set out the minimum requirements for safe construction. The heat exchanger industry recognized that these rules applied to vessel construction only, and left glaring voids when applied to heat exchangers. To fill this need, the standards of Tubular Exchanger Manufacturers Association were developed. These standards, which supplement the vessel construction codes, have become accepted as a code for the safe construction of exchangers. The cost data presented in this paper are based on TEMA construction.

Costs—Figure 4 shows the cost per square foot of external tube surface of ¾-inch tubed floating head exchangers. The cost curves of ¾-inch, 16-foot tubes on 15/16 triangular pitch and ¾-inch, 20-foot tubes on 1-inch square pitch are so nearly alike that the curves almost coincided. For estimating purposes the cost can be considered identical. It will be noted that the cost per square foot of surface decreases rapidly in the small surface range and tends to level out for the larger exchangers. This relation holds true regardless of the type of construction.

Figure 5 shows cost data for 1-inch, 16-foot tubed exchangers on 1¼ square and triangular pitch. Cost figures for 1-inch, 20-foot tubes were omitted for this diameter-length combination is seldom used.

Figure 6 shows cost curves for U-tube exchangers with ¾-inch 16- and 20-foot tubes on 1-inch square and 15/16 triangular pitch. Here again, the cost per square foot of 16-foot tubes on triangular pitch is almost identical with 20-foot tubes on square pitch so a single curve is used. In describing a U-tube exchanger the 16-foot or 20-foot dimension refers to the nominal bundle length. The tubes from which these bundles are fabricated are actually twice the length of the bundle.

Figure 7 shows cost curves for 1-inch tubes in 16-foot bundle length U-tube exchangers on 1¼ square and triangular pitch. As in the case of the floating head units, the cost per square foot, using 1-inch tubes is greater than in ¾-inch tubed exchangers.

Figure 8 shows cost curves for ¾-inch, 16- and 20-foot and 1-inch, 16-foot tube length fixed tube sheet exchangers with the tubes on triangular pitch. Since the shell side of these units is inaccessible for cleaning, triangular pitch is almost universally used to achieve the lowest cost per square foot.

Figures 9 and 10 show the additive costs based on bundle diameter for pull through floating head units and two pass shell units with expandable longitudinal baffles. Pull through floating head construction permits removal of the tuble bundle without first removing the shell cover and the floating head cover. However, to accomplish this it is necessary to increase the shell diameter to allow passage of the floating head closure. With this construction, adequate

sealing between the shell inside diameter and the bundle periphery must be provided to prevent excessive fluid by-pass. The two pass shell unit is used as an economic expedient where, due to temperature ranges, it is necessary to achieve counter-current flow conditions or conditions approaching counter-current flow. This can be accomplished by using a number of shells, but, referring back to Figure 4, it can easily be seen that it costs less to buy a two pass shell of large surface rather than two smaller surfaced shells stacked in series.

Figure 11 shows comparative costs for other materials of construction for the ¾-inch, 14-gage, 16-foot steel tubed exchangers with tubes on 15/16 triangular pitch. For estimating purposes, approximately the same cost ratio as shown here will exist in the U-tube and fixed tube sheet exchangers.

Figure 12 is presented to give an indication of the magnitude of increase in cost with an increase in pressure. This relationship is not necessarily valid for other types of construction, or floating head exchangers with different tube pitch, length and diameter. Since in high-pressure design, many construction variations are possible which will reduce the over-all cost, it is advisable to discuss each problem with the manufacturer.

In determining the most economical selection of exchangers, the process engineer should consider the longitudinally finned, double-pipe section which can be arranged in series-parallel banks to form an exchanger system. This type of exchanger is most economical for low flow rates, fluids with widely different heat transfer characteristics, and when counter-current flow is not economical in shell and tube exchangers. The cost of finned surface for the standard 100-square-foot section in steel construction is approximately $2.50 per square foot; with Admiralty finned tubes, the cost is approximately $3.50 per square foot.

The shell and finned tube exchanger having the widest range of application employs low circumferentially finned tubes having an outside tube surface from two to three times that of the corresponding bare tube. The surface is highly efficient, and economies can be attained, especially where the surface requirement is large. As in the longitudinally finned units, the greatest saving results when the heat transfer characteristics of the two fluids are widely different.

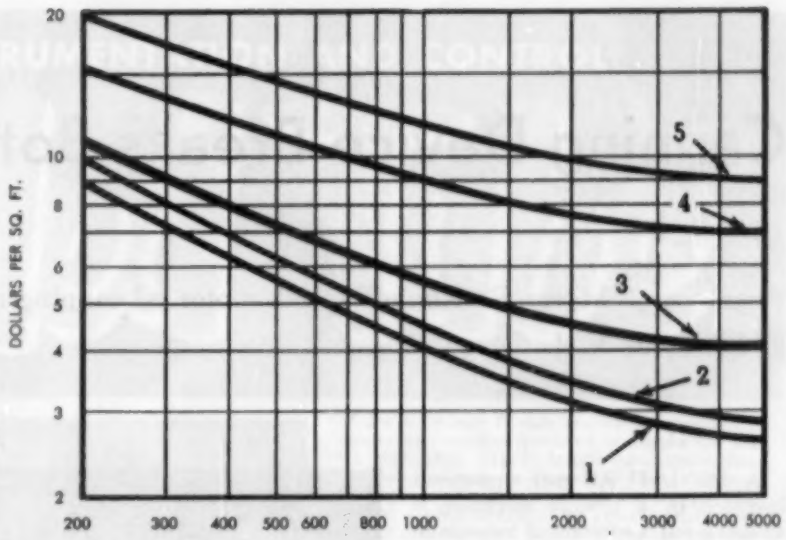


Figure 11. Variation of costs with construction material for floating head exchangers, ¾" (od) x 16-foot tubes on 15/16" triangular pitch, 150 psi design pressure. (1. 14 Bwg tubes, all steel; 2. 16 Bwg tubes, aluminum bundle and channel; 3. 16 Bwg tubes, all brass bundle; 4. 14 Bwg tubes, 4-6 chrome bundle; 5. 16 Bwg tubes, 304 stainless bundle and channel.)

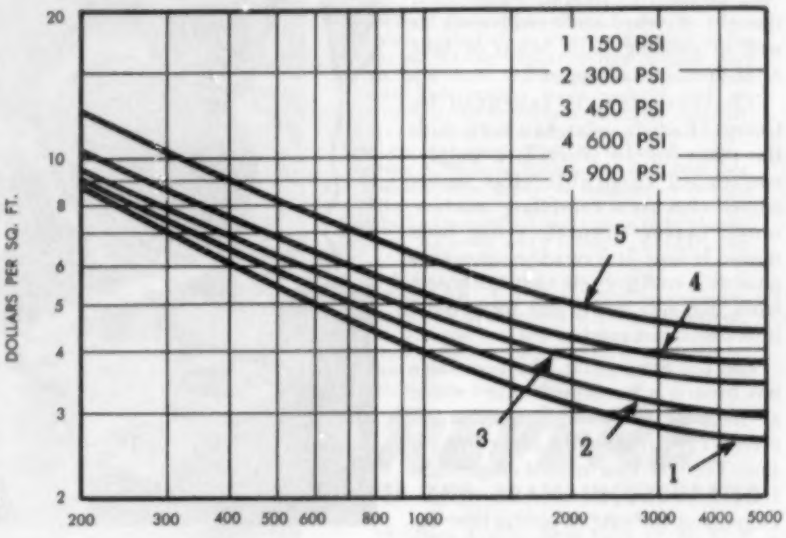


Figure 12. Costs for all steel floating head exchangers, ¾" (od) x 14 Bwg tubes on 15/16" triangular pitch.

Conclusion—These cost curves were presented to give actual cost data rather than ratios and trends. The exchangers required by new, high-temperature processes do not lend themselves to clear presentation on a cost curve. In most cases, pressures, temperatures and materials are different on the shell and channel sides with the result that each requirement is a specific design problem. For estimating costs of these exchangers it is best to discuss the problem with the manufacturer, who will develop costs for the specific designs required.

Original presentation was at the Ninth Annual Petroleum Mechanical Engineering Conference, ASME, Los Angeles, September, 1954. ##

Canning Device Breaks Bottleneck

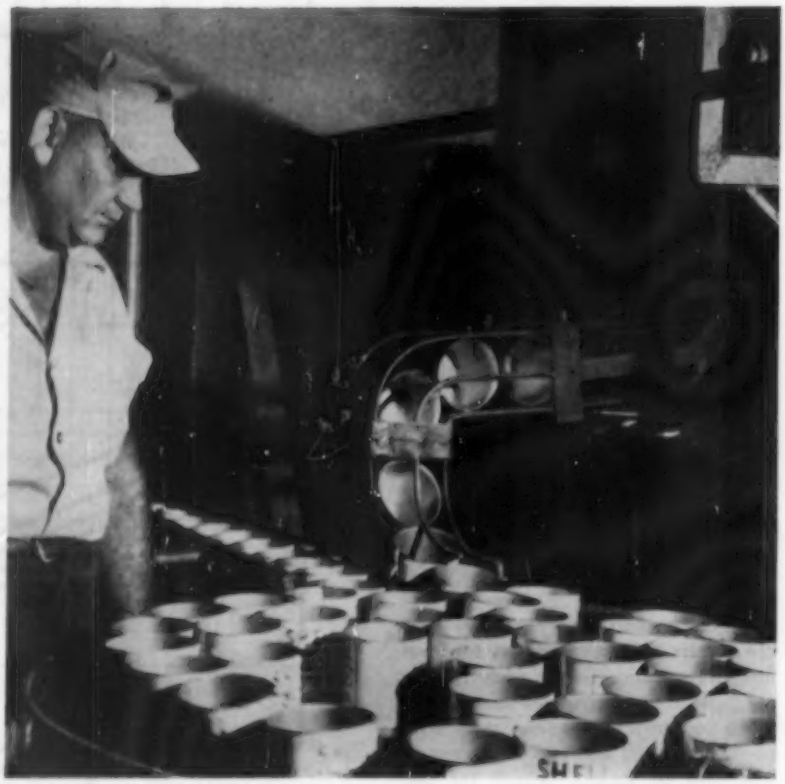
"Merry-Go-Round" speeds motor oil canning at Shell Oil Company's plant at Sewaren, N. J.

A MINIATURE merry-go-round invented by a veteran mechanic is spinning out a substantial increase in canned motor oil production at Shell Oil Company's Sewaren, N. J., canning plant. According to Shell engineers, it may lead to a minor revolution in the canning industry. They say the idea behind the invention—"so simple it should have been thought of years ago"—will work as well in canning soup, beans or beer as it does in canning oil.

The new device, invented by George Radich, who has been with the plant for 19 years, is a simply-constructed turntable that moves empty cans to a can-filling machine much faster than they had been moved before. It serves the same purpose as a traffic circle that takes cars from two side roads and feeds them into one main road.

For the Shell plant, the turn-table has broken a bottleneck that existed as long as a canning machine received cans from only one conveyor line. The conveyor moved empty cans from a box car to the canning machine, and the rate of production was limited because there was no way of maintaining an uninterrupted flow of cans from the car to the conveyor to the machine. Radich decided to unload two or more cars at once and feed the combined output to the canning machine over a single conveyor line.

To do this he put up two feeder conveyors—to unload cans from two cars at once—and fed the two lines of cans on to the turntable. The table feeds all the cans on to a single conveyor that goes to the canning machine. Now the conveyor is always full of cans and the machine can operate at full capacity.



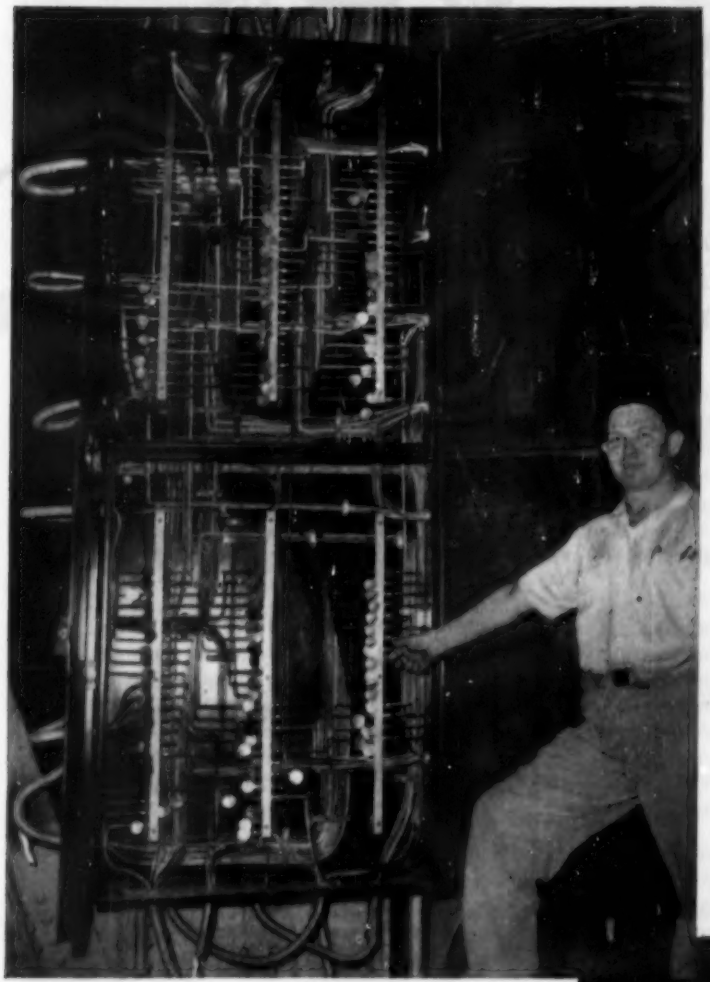
Can "unscrambler" enables empty oil cans to speed through the juncture of chutes inbound from two railroad cars, thus reducing a major bottleneck.

Shell has installed four of the turntables, serving machines that fill cans of various sizes. Production has risen from a daily average of 2800 cases of 24 cans each to 3800 cases. It is expected to reach 5000 cases a day in 18 months.

The turntable, which Radich calls an "Unscramble," is a slowly-revolving, flat metal disc about three feet in diameter. Aside from the speed at which it turns—which must be carefully regulated to ensure receiving and discharging cans at the desired rate—the essential feature of the Unscrambler is an automatic brake that guides oncoming cans to the outer edge of the table and keeps them from knocking each other down. Shell has announced its willingness to license the manufacture of the device in the belief that it may be put to more general use. ##

FOR INSTRUMENTATION AND CONTROL

Cabled Tube



Some time ago Revere ran an advertisement featuring Crescent Armored Multitube for use in pneumatic and hydraulic instrumentation and control systems. The advertisement created so much interest that we thought you might like to see a photograph of an actual installation. The Control Board Junction Box shown here has 22 runs of Multitube coming into this box comprising 224 Revere Copper Tubes of 1/4" O.D. The picture was taken in the Glenwood Landing, N.Y. Power Station of the Long Island Lighting Company. The tubes go to instruments that report information on temperature, main and reheat steam pressure, boiler feed and condensate pump pressure, fuel oil and gas pressure, liquid levels, tide level and for the control of fuel feed, draft dampers, boiler drum water level and various control valves.

This is a relatively new use for Revere Copper Tube, but it is an important one in these days when new ways are being found to obtain process information more quickly and accurately, or to achieve automatic control. Crescent Armored Multitube is made by Crescent Insulated Wire & Cable Co., Inc., Trenton 5, N.J., in lengths up to 1,000 feet. It consists of a group of long tubes twisted together in cable form, protected by a flexible interlocked galvanized steel armor, or by plastic, or both. As many as 19 tubes, 1/4" O.D., can be cabled, with one tube in each layer color-coded. Larger tubes can also be cabled, including 5/16", 3/8" and 1/2". This construction affords protection during shipment, installation and use, and speeds up installation greatly. For further information, write Crescent, and for tube in copper and aluminum, see the nearest Revere Sales Office.

REVERE

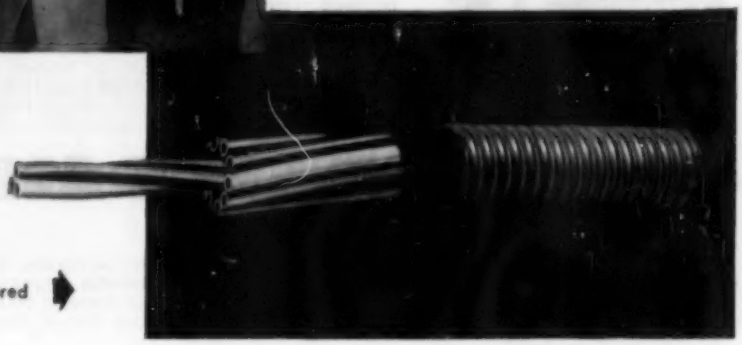
COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

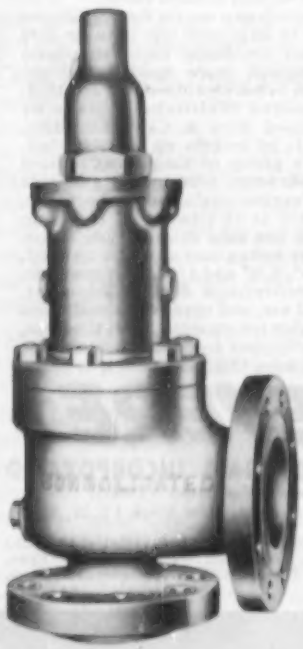
Control Junction Box at Power Station of Long Island Lighting Company, showing use of Crescent Armored Multitube. Note that relatively sharp bends can be made without damage to the cabled copper tube.



Construction of Crescent Armored Multitube.

NOW... CONSOLIDATED SAFETY RELIEF VALVES in economical "2 in 1" design

Peak performance . . . positive valve action assured . . . even where discharge lines are long, or low "superimposed" back pressure exists in the relieving system.



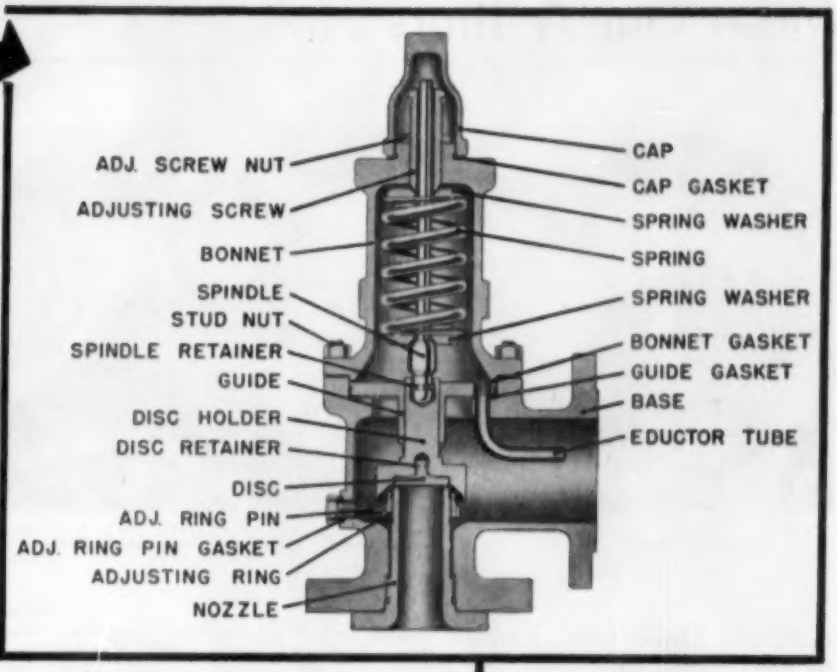
"Two-In-One" design, improved performance . . . the new Consolidated Safety Relief Valve is the result of over 4,000 flow tests in 5 years at West Edmond, Oklahoma. At the A.S.M.E.-approved testing station there, natural gas is available in flow capacities up to 35,000 cfm and pressures up to 500 psig. The A.S.M.E.-approved conditions, apparatus, and procedures permitted Consolidated engineers to test-develop and prove the full range of valve sizes and pressures in both Standard and Bellows designs.

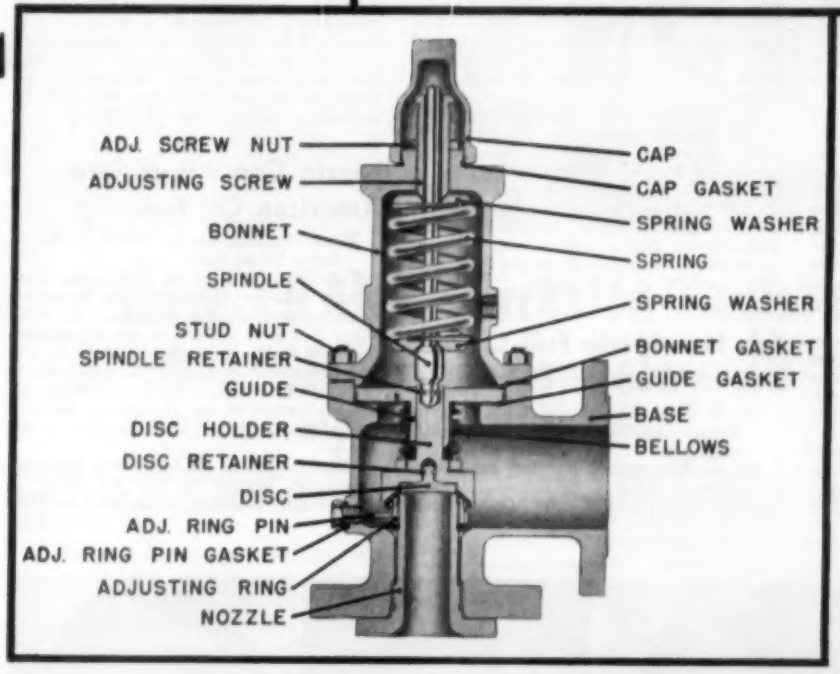
Interchangeability is so highly developed that the majority of Consolidated Standard Valves can be converted to the Bellows design, in the field, simply by installing the bellows. Each type has fewer functional parts than other comparable safety relief valves. Standardization of inlet and outlet center-to-face dimensions permits interchangeability with a large proportion of the valves of other manufacturers. Incorporated is an optically-ground flat seating surface that contributes to easier, more economical maintenance.

You can have the absolute protection and real economy of the thoroughly tried and proved Consolidated Safety Relief Valves for your plant today. Both Standard and Bellows types are available in sizes and pressures to meet requirements of the most advanced processing facilities. Write for full details. Ask for Catalog 1900.

CONSOLIDATED SAFETY RELIEF VALVES

STANDARD VALVE has an eductor tube that holds the pressure in the valve bonnet to approximately atmospheric pressure; thus only the force of the spring controls the valve. Valve action is improved and stabilized . . . repetitive flow capacity is provided . . . a new high in operational dependability is assured. Even under repeated popping of the valve, set pressure and blowdown are consistent. The valve will open to full capacity at 3% overpressure regardless of the position of the adjusting ring.





BELLOWS VALVE is like the Standard but has a durable, two-ply stainless steel sealing bellows which effectively isolates from the valve's working parts any contaminants, corrosion, or viscous fluids. The bellows is balanced with the seating surface: set pressure of the valve is not affected by back pressure, whether constant or variable. Consequently, smaller discharge piping can be used, thus reducing the cost of pressure-relieving systems.

Certified and Approved

Both Standard and Bellows Valves are approved under A.P.I.-A.S.M.E. Unfired Pressure Vessel Codes, A.S.M.E. Unfired Pressure Vessel Code and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

CONSOLIDATED 1879 U.S.A.

A PRODUCT OF MANNING, MAXWELL & MOORE, INC.

TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

For more data on advertised products, use Readers' Service Cards, last page.

Meet Our Authors . . .

Paul W. Tucker | Geo. R. Benz | W. F. DeVoe | H. A. Erb

Authors, One, Two, Three in LPG Forecast Series

George R. Benz, Paul W. Tucker and W. F. DeVoe, "LPG Demand to Climb," page 108.

This is George R. Benz' third time to participate in PETROLEUM REFINER's annual look at LPG demand; it is Paul W. Tucker's second, and W. F. DeVoe's first.

Much of the 26 years Benz has been with Phillips Petroleum Company has been in the LPG field. Today he is manager of the Engineering department, having previously served in such capacities as research engineer, sales and service engineer, and manager of LPG sales. Author of 12 published articles on liquefied petroleum gases, he is a member of the Liquefied Petroleum Gas Association, serving as chairman of the transportation committee and on the board of directors. He was graduated from the University of Kansas in 1925.

As technical representative of Phillips' Engineering department, Tucker is concerned with various technical and regulatory aspects of LPG. He has been with Phillips since 1948, going there from Tennessee Eastman Corporation. He attended William Jewell College, Louisiana State University, the University of Illinois and the University of Missouri, receiving a Ph.D. degree in chemistry from the last named.

DeVoe, assistant to the sales manager at Phillips, is assigned to Phillips LPG sales. He joined Phillips in 1940, having previously been with Charles A. Hones, Inc., as a sales engineer. Among positions he has held at Phillips: manager of the Detroit district office; manager of the Philadelphia district office, and assistant manager and manager of product procurement for LPG at Bartlesville.

Erb Has Made Full Circle In His Work at Elliott

H. A. Erb, "Centrifugal Compressor Symposium, Theory of Operation," page 123.

H. A. Erb started working for Elliott Company in 1928 as an apprentice engineer on centrifugal compressors. Since then he has worked progressively on steam turbines, steam engines and electrical equipment, and then back to steam turbines and finally back to centrifugal compressors, completing the cycle. Today he's the Compressor division engineering assistant to the vice president. He holds an E.E. degree from Cornell University.

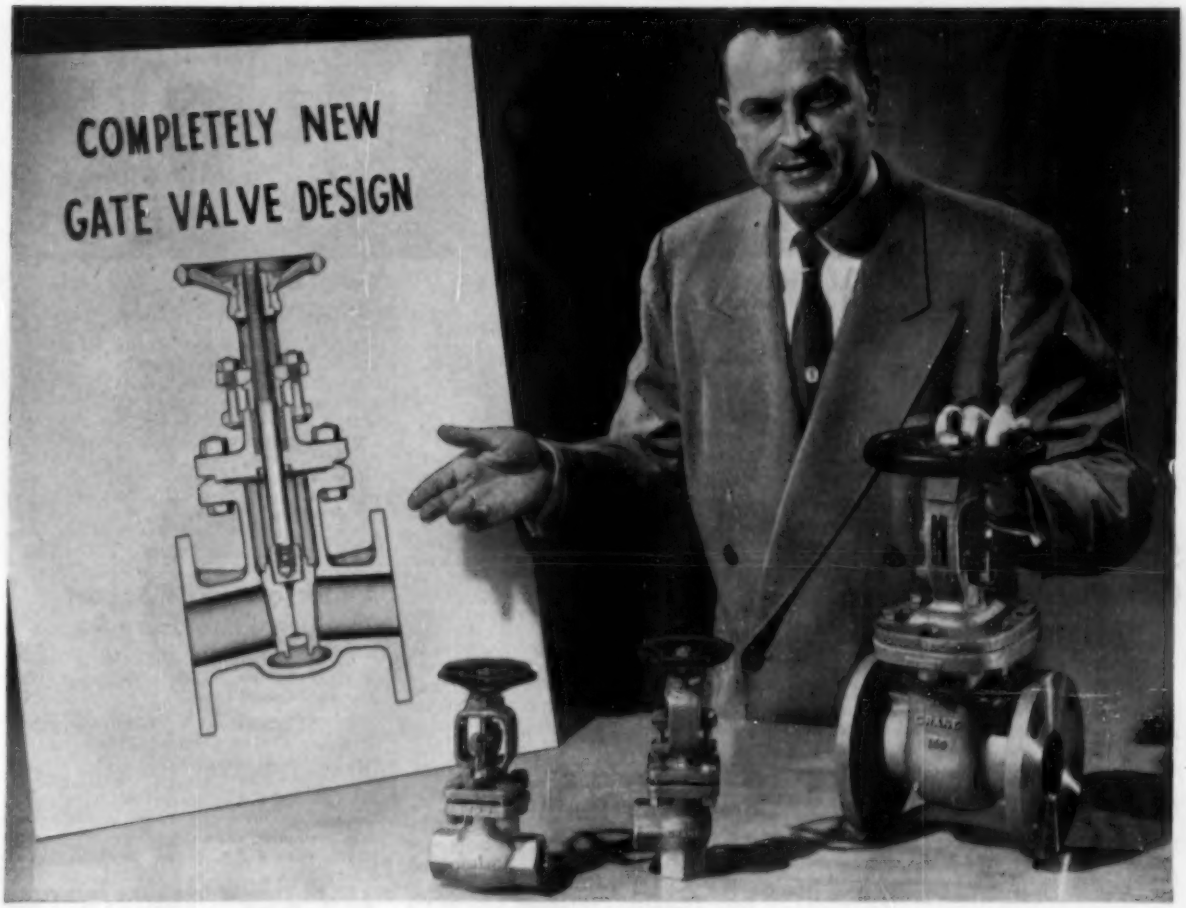
Laszlo Can Appreciate American Oil Industry

Tibor Stephen Laszlo, "How to Desulfurize Diesel Fuel," page 115.

For 13 years after his graduation from Joseph Palatine University for Technical Sciences at Budapest, Hungary, in 1935, Tibor S. Laszlo worked in the oil refining industry in Hungary. For a while he was associated with Steaua, S. A., a subsidiary of Anglo-Iranian Oil Company. After the nationalization of the Hungarian industry by the communists in 1948, he came to the U. S.

His first job in the U. S. was directing a research project for the Air Force on a jet engine problem. From 1951 to 1953

Tibor S. Laszlo | Orin A. Smith | Clark Shields | T. P. Latimer



New CRANE Corrosion-Resistant Valves in 18-8 SMo and Craneloy 20

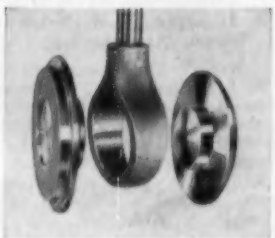
Gate, Globe and Angle Patterns

Few valves for process industries have ever received the quality treatment given this new Crane line.

Note, for instance, the unique yet simple split-wedge disc construction in the gate valves. Those dual identical discs are free to rotate in their holder—the most effective design for resisting galling. The trunnion shape at the back of each disc assures even distribution of closing forces. You couldn't buckle them if you tried.

The globe and angle valves give equally outstanding control of corrosive fluids. A new type disc-stem connection, with minimum clearances, practically eliminates vibration. By placing seating load closer to seats, it provides easier, more accurate closure.

Throughout, these valves are built for better service in your choice of Crane 18-8 SMo Stainless Steel or Craneloy 20. Both lines come with screwed or flanged ends. Full information given in circular AD 2059—available from your Crane Representative or on request to address below.



New split-wedge disc in gate valves combines the benefits of free rotation with uniform seat load pressure.

CRANE CO.

General Offices: 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

CRANE'S FIRST CENTURY . . . 1855-1955

For more data on advertised products, use Readers' Service Cards, last page.

T. W. Pickel G. W. Wilson R. E. Kelley D. M. Boyd E. D. Anderson E. W. Flaxbart

he was a process engineer in the Research and Development department of California-Texas Oil Company. Since 1953 he has been associate director of the high temperature laboratory at Fordham University, New York.

Laszlo lists his preferred activities as travel (he went to Australia last year), books, music and all sports.

Smith Covers Selection of Centrifugal Compressors

Orin A. Smith, "Centrifugal Compressor Symposium, Specification and Selection," page 136.

Orin Smith is a product engineer, centrifugal compressors, at Worthington Corporation, Harrison, N. J. As such he is concerned with the application, selection and design of centrifugal compressors.

Smith previously worked as electrical draftsman and detailer at Fay, Spoffoid & Thorndyke; and as research and development engineer at Worthington.

Born in Brooklyn, he was graduated from Northeastern University, Boston, Mass., with a B.S. degree in mechanical engineering.

Kelley, Pickel, Wilson: Co-Workers at Baytown

R. E. Kelley, T. W. Pickel and G. W. Wilson, "How to Test Fractionators, I," page 110.

R. E. Kelley, T. W. Pickel and G. W. Wilson spend their working hours together in the Technical Service division of Humble Oil & Refining Company's Baytown, Texas, refinery.

Kelley has been with Humble three years, and, as a chemical engineer, he is presently concerned with production of aromatic solvents, fractionation, extraction and crystallization. He holds B.S. and M.S. degrees in chemical engineering from Rice Institute.

Another Rice alumnus is Wilson, who received a B.S. degree in chemical engineering there in 1935. At Baytown his work is in connection with light oil treating, rerun distillation and pollution abatement.

Pickel is assistant chemical engineer at Humble and works in connection with catalytic cracking units. He joined Humble in 1951 soon after being graduated from Vanderbilt University with a B.E. degree in chemical engineering. He also attended Milligan College from 1945 to 1946.

Meet Our Authors. . .

Shields Works With Centrifugal Compressors

Clark T. Shields, "Centrifugal Compressor Symposium, Process and Mechanical Design," page 132.

As product specialist, centrifugal equipment, at Carrier Corporation, Clark Shields is responsible for company-wide coordination of centrifugal compression and refrigeration sales and application. Since joining Carrier in 1936 he has served as test engineer, centrifugal development; field test engineer, centrifugal refrigeration; first engineer in and then head of the Application Engineering department. He's held his present post since 1949.

He attended Union College, Schenectady, winning a B.S. degree in chemical engineering and two varsity track letters.

Latimer Looks Over Compressor Performance

T. P. Latimer, "Centrifugal Compressor Symposium, Important Performance Characteristics," page 130.

Since February, 1949, T. P. Latimer has been associated with Clark Bros. Company, Olean, N. Y. He is presently manager of the Turbo-Machinery Engineering Sales department. He studied engineering at Cornell University. A bachelor, he enjoys sailing and golf during his leisure hours.

Boyd Goes After What He Wants—And Gets It

David M. Boyd, Jr., "Why Electronic Process Control?," page 155.

Seven years ago doctors told David Boyd's family that he would never walk again. A victim of polio, Boyd had before him a life in an iron lung. Within a few months, however, he was walking. How did he do it? His answer: the doctors forgot to tell him he couldn't walk again.

The same rugged determination which got him on his feet characterizes all of Boyd's activities. At Universal Oil Products Company, which he joined six and a half years ago, he's known by the nickname, "Little Bulldog." Dr. D. J. Bergman, chief engineer for UOP, says of Boyd: "You can always rely on him to be starting trouble for someone which will result in better automatic control some place."

Electronics has been Boyd's hobby since he was graduated in 1941 from the University of Colorado with a B.S. degree in chemical engineering. While he was working for Barrett Chemical Company in Philadelphia, officials of the company heard about a television set he had built in his spare time and transferred him to the Instrument department. After about a year he joined Blaw-Knox Company, working on a design for synthetic rubber plants. A year and a half later he was head of the Instrument department for Eastern States Petroleum Company in Houston. He contracted polio while assigned to the Oak Ridge, Tenn., National Laboratories, where he worked on projects for the Atomic Energy Commission on loan from Monsanto Chemical Company.

Anderson and Flaxbart Produce Economics Paper

E. D. Anderson and E. W. Flaxbart, "Economics of Heat Exchanger Design," page 159.

E. D. Anderson is chief engineer at Western Supply Company, Tulsa, Okla. His previous associations include those with Shell Oil Company, Fraser Brace Engineering Company and Brown Fintube Company. Born at Marinette, Wis., he was graduated from the University of Wisconsin with a B.S. degree in chemical engineering.

E. W. Flaxbart is a rating engineer at Western Supply, and, as such, he is concerned with thermal design and sales. Since his graduation from the University of Tulsa in 1949 with a B.S. degree in petroleum engineering, he has engaged in design and sales of heat exchange equipment. He attended the University of Kansas, College of Engineering, prior to matriculating at Tulsa.

Fleming Knows His Way In Industrial Medicine

Allan James Fleming, "Is Poor Health *Really* the Price of Success?", page 211.

Dr. Allan J. Fleming, assistant medical director at E. I. du Pont de Nemours & Company, has been working in industrial medicine since 1935.

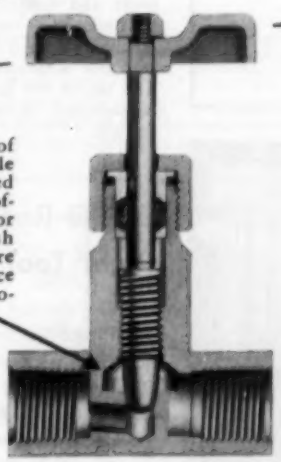
Born in Winnipeg, Manitoba, Canada, Dr. Fleming won his B.S. degree in physics from the University of Manitoba in 1924 and his M.S. degree in 1926. Following a short period during which he taught, he entered medical school at McGill University, Montreal, emerging in 1932 with an M.D. degree.

After two years as plant physician at the Beloeil plant of Canadian Industries Ltd., he joined du Pont in 1937 as a toxicologist in the Haskell Laboratory for Toxicology and Industrial Medicine. In 1941 he was made assistant director of the lab and in 1948 was appointed assistant director of the company's Medical division.

He belongs to a number of medical associations, in both the U.S. and Canada.

MAXIMUM WORKING PRESSURE
10,000 PSI
for water, oil or gas

- Body and stem guide extra heavy bar stock fused into one piece.
- Valve stem 416 stainless steel.
- Packing special one-piece "Marpak" moulded ring.
- Bodies marked in accordance with MSS regulations.



ONE PIECE

The stem guides of conventional needle valves are screwed into bodies—this often causes leakage or blow-outs. Marsh Needle Valves are fused into one-piece by exclusive "Conoweld" process.

The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

Write today for catalog giving complete details.

MARSH INSTRUMENT CO. *Sales Affiliate of Jos. P. Marsh Corporation*
Dept. R, Skokie, Ill. • **Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta** • **Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas**

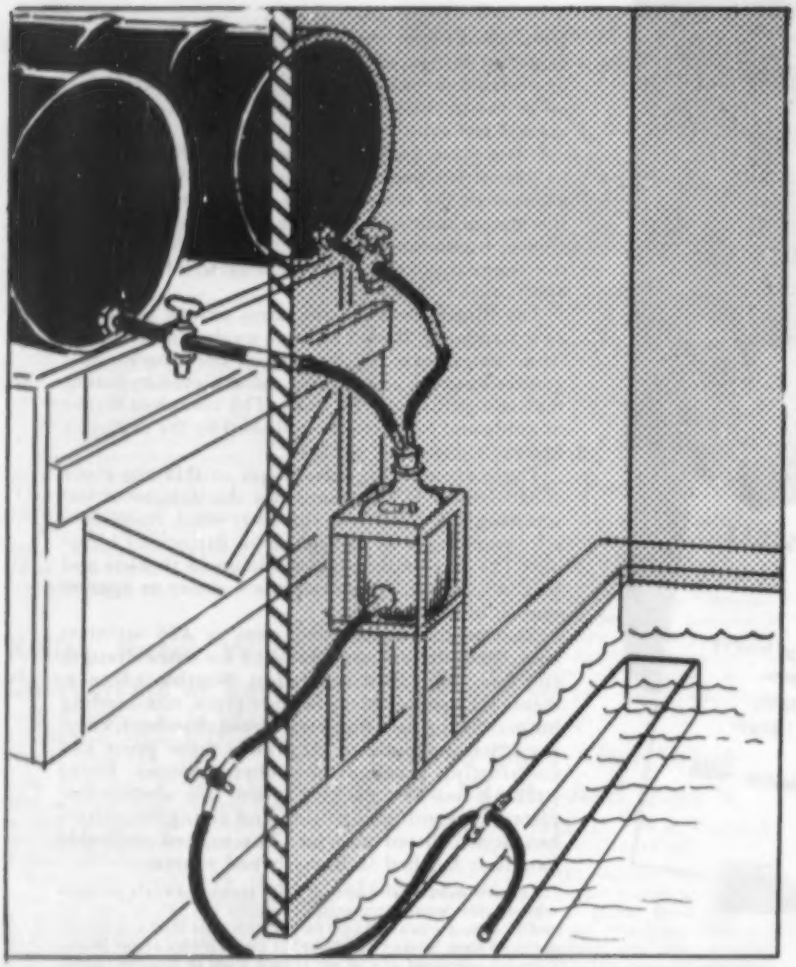
MARSH

"THE STANDARD OF ACCURACY"

For more data on advertised products, use Readers' Service Cards, last page.

How to Do It . . .

$10 is paid for each accepted idea. Mail to Editor, Petroleum REFINER, P.O. Box 2608, Houston, Texas

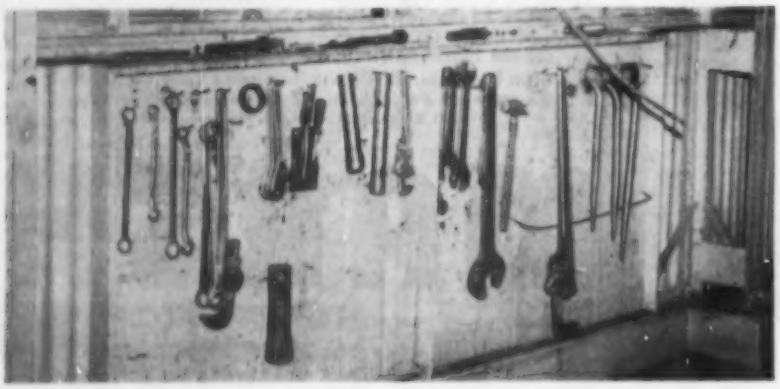


System Minimizes Danger Of Sulfuric Acid Handling

Control of the pH in water circulated through cooling towers is normally done by the addition of sulfuric acid since the water tends to run on the alkaline side. Handling concentrated sulfuric acid is tricky and can be dangerous. This system makes use of readily available materials to minimize the possibility of the operator's coming into contact with the acid.

The acid is stored in two drums which are mounted on a raised platform. This allows the use of gravity flow for injecting the acid. A metal adapter fits into the bung hole of each barrel. To this adapter fits a length of plastic hose and a glass valve. The plastic hose runs to a large two-hole stopper in the top of a glass one-gallon bottle. This bottle is calibrated so that the operator can determine how much acid he is adding during any given time interval. The glass bottle has an outlet near the bottom. Another length of plastic hose is attached to this bottom outlet and runs to a wooden trough. A glass valve is inserted in this line.

The acid, then, drains through this hose down into the trough which is partly submerged in the water. This trough is roughly six inches across and ten inches deep and has holes cut in the sides for the water to enter and mix with the sulfuric acid. The arrangement provides mixing of the water and the acid instead of allowing the high specific gravity acid to settle and concentrate at the bottom of the basin. With the exception of the drums, all material used is highly resistant to the corrosive action of the concentrated acid. The use of two drums allows one drum to be switched without interrupting acid injection.



Engine Room Toolboard: Right Tool at Right Time

The right tool in the right place at the right time—a never ending problem for the man who must make quick repairs. The photograph shows one solution—a tool board mounted on the wall of the engine room with all small hand tools easily accessible and clearly displayed.

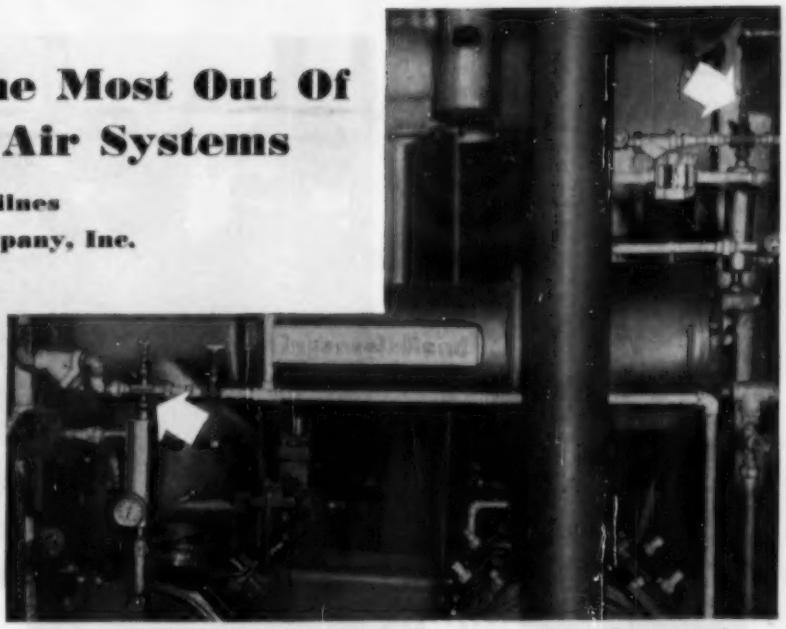
More How To Do Its Page 174

How To Get The Most Out Of Compressed Air Systems

A. Milnes

Sarco Company, Inc.

THE practical place to measure the capacity of your compressed air system is where it counts the most—at your compressed air tools. From the time air is first drawn into the cylinder, many things can happen which will effectively reduce air pressure and limit compressor capacity. Following is a concise explanation of the major causes of reduced compressor capacity and the steps which can be taken to remedy them.



The replacement of hand controls by Sarco automatic cooling controls on this 2-stage Ingersoll-Rand compressor resulted in better lubrication, less condensate in air, and a considerable saving in cooling water.

PROPER AIR INTAKE

Your compressor system can be fouled up before a pound of air has been compressed if the air intake has been improperly located. The air intake should be located where the atmosphere is clean, cool, free from corrosive chemical fumes, and dry to minimize condensation in the system.

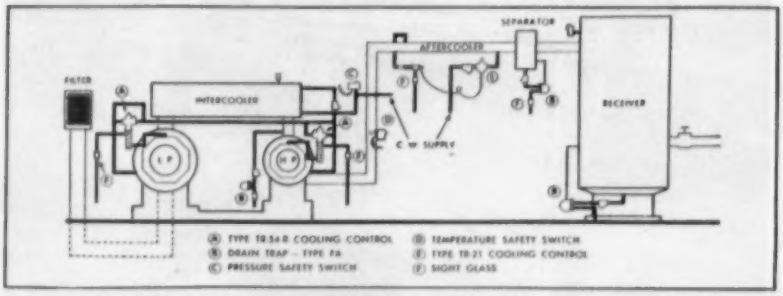
INTAKE PIPE DESIGN

A compressor can only operate at rated capacity if its air supply is unimpeded. Twisting, undersized pipes and dirty filters can effectively reduce air pressure at the compressor inlet. For example, a pressure loss of 2 psi due to friction in the intake pipe and filter will reduce the output of a 125 psi compressor by 7.5%. Check intake pipes and make sure they are short, of adequate size, and free of sharp bends.

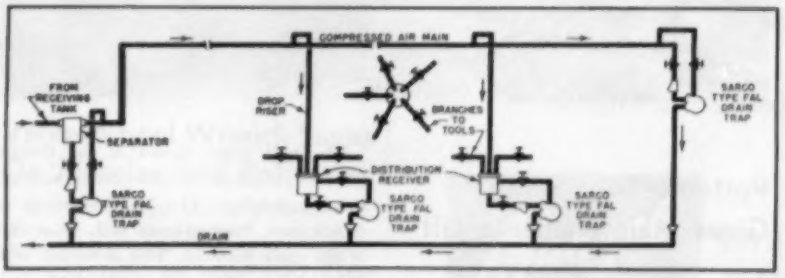
AUTOMATIC COOLING CONTROL

One of the major causes of inefficient compressed air operation is unbalanced cooling. For example, overcooling wastes water, causes deterioration of compressor lubricant by condensation in cylinder head. On the other hand, undercooling reduces compressor capacity, may result in serious damage to cylinders, pistons, valves and seats.

To offset this, many compressor manufacturers such as Schramm, Ingersoll-Rand, and others install Sarco automatic cooling controls at the factory. These controls are self-modulating, insure optimum cooling effect with minimum water consumption regardless of load variation, changes in pressure and temperature of water supply.



Sarco cooling controls are installed to regulate the water supply to cylinder jackets so that jacket discharge temperature is between 100-115° F.



Drain traps at critical points in the distribution system effectively remove condensate — protect compressor equipment, tools, and work.

(Advertisement)

CONDENSATE REMOVAL

If condensation is not kept to a minimum serious damage can result to tools, paint surfaces, molds, etc. Other results of excessive condensation in the system are water hammer and freezing of mains, receivers and tool exhausts.

To prevent this, well-designed compressed air systems usually have Sarco drain traps installed at the aftercooler, on separators, at receivers, and on low points in the lines to remove water as quickly as it collects.

FREE TECHNICAL ADVICE

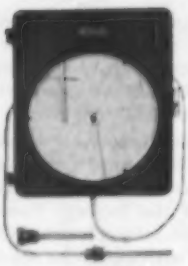
Sarco engineers have prepared a technical bulletin designed to pass on to compressed air users practical advice on how to improve air compressor operation. It also contains simple hook-ups of Sarco cooling controls and drain traps.

This bulletin may be obtained without obligation by writing the Sarco Company, Inc., Empire State Building, N.Y. 1, N.Y. Also represented in principal cities.

4½" DIAL THERMOMETERS

Made in 3 types to suit any requirements. Rigid stem, wall or flush mounted, 11 inches of scale reading. Interchangeable with standard industrial separable sockets. Stem can be placed at any angle and case can be rotated to any readable position.

PALMER
MERCURY ACTUATED
Temperature Indicating Instruments



RECORDING THERMOMETERS

Twelve inch die-cast aluminum case with black or white wrinkle or satin finish. Single or multiple pen construction. Electric or spring wound clock, 24 hour or 7 Day Revolution. Flexible Armor and bulb of stainless steel. Ranges —40 +950°F or Equivalent in °C.

INDUSTRIAL THERMOMETERS

Red-Reading Mercury —Extruded brass case — chrome finish. Ranges —40 + 950°F or Equivalent in °C.

RED-READING MERCURY LABORATORY THERMOMETERS

Thoroughly annealed for permanent accuracy. Complete line A.S.T.M. and fractional division types.

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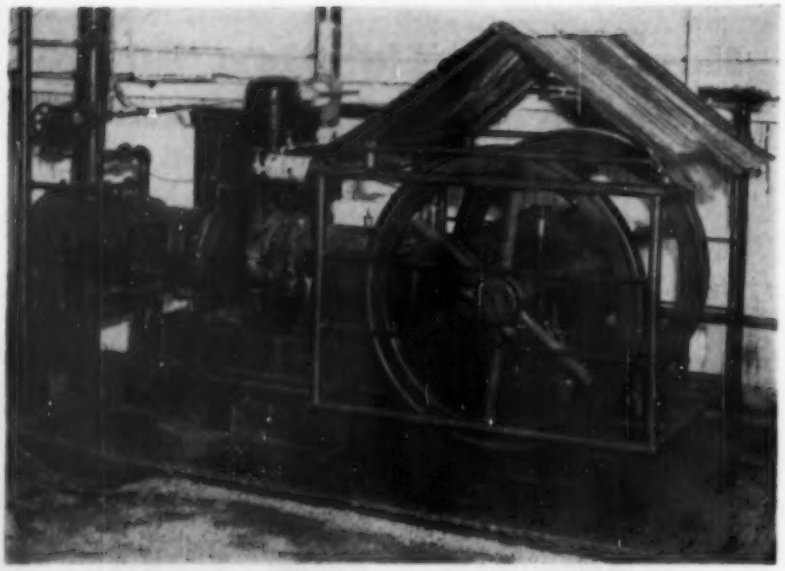
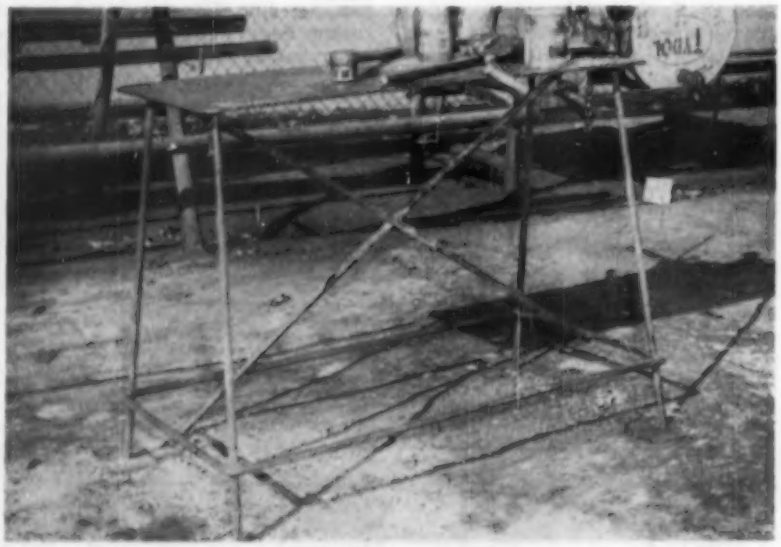


Simple Housing Protects Engine

The ancient engine shown in the photograph may owe a part of its longevity to the effective housing constructed by a thoughtful maintenance crew. Simply constructed of scrap sheet iron, the housing is supported by welded sections of ¾-inch pipe.



Portable Tool Stand Gives Maintenance a Lift

How to Do It . . .

The tool stand shown in the picture features simplicity of construction and unusual portability. The legs are made of 1-inch pipe, strengthened with cross cuts of the same material. This is topped with a 3 x 6-foot section of quarter-inch sheet metal. On one end of the top is mounted a light weight pipe vise. To the bottom

of the legs are attached small squares of sheet metal to insure rigidity.

Sturdy Dolly Moves Heavy Equipment in Shop

The illustration pictures a shop-fabricated dolly that is proving a strong right arm to the maintenance crew at an East Texas natural gasoline plant. Sturdily constructed of welded sections of 3-inch pipe, the dolly is equipped with a block and tackle for handling heavy equipment. Mounted on coasters, it can be easily moved to any part of the shop building.

Valve Wheel Wrench Saves On Muscles and Patience

The photograph shows a home-made 16-inch valve wheel wrench designed by the operator using it. The two tongues extending from the wheel end of the wrench are bent in opposing directions to insure secure attachment to the wheel.

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Who's Building . . .

Texas Natural Gasoline Building Gasoline Plant In Coke County, Texas

Construction has started on a Texas Natural Gasoline Corporation natural gasoline plant to process natural gas from the Jameson Strawn Sand Field and the Fuller Coke Sand Field, located in northwestern Coke County, Texas.

The plant is being built by Texas Natural Gasoline and will have a capacity in excess of 70 Mmcf a day. It will utilize the casinghead gas now being flared to the atmosphere in the field. The facility will produce natural gasoline, butane, isobutane and propane. Cost of the plant was not announced.

The gathering system and gas compressor plant will begin operations by March 1, 1955, and the fractionating portion of the plant by August 1, 1955. It is estimated that when the plant is processing 70 Mmcf a day and upon completion of current additions to the company's other plants, Texas Natural Gasoline's production of natural gas liquids will be in excess of 800,000 gallons daily.

Philippines' First Is $30 Million Plant

Continued from Page 97

by Caltex (Philippines), the refinery has a thruput capacity of 13,000 barrels of crude oil a day. It incorporates the latest developments in refinery construction and will produce motor gasoline, illuminating kerosine, automotive diesel, industrial diesel, bunker diesel, bunker fuel oil and land fuel oil.

Site of the new installation is on Batangas Bay, 72 miles south of Manila.

Refinery construction began in 1952 and was completed three months ahead of schedule.

The major refinery processing units include:

- A two-stage crude distillation unit, to which the crude oil is fed in the first stage of the refining process. One main column operates at atmospheric pressure and the second under vacuum. This unit produces straight-run gasoline, kerosine, diesel gas oil and residuum.
- Propane decarbonization unit processes the vacuum residuum from the crude unit and prepares feed stock for the cracking unit.
- Fluid catalytic cracking unit processes a feed mixture from the crude and decarbonization units into a high-octane gasoline blend stock.
- Polymerization unit processes certain light petroleum fractions from the catalytic cracking unit into additional high-octane motor gasoline blending components.

Ancillary units at the refinery include a transfer pumphouse, steam electric power plant, tankage and transfer lines, administration offices, maintenance shops, a storehouse, cafeteria and a hospital and dispensary.

Second Fluid Hydroformer Almost Ready—

Construction is nearing completion on this new Fluid Hydroformer being built at the Cities Service Oil Company's refinery at East Chicago, Ind. Large tower at left marks the site of combination naphtha-recycle gas furnace. Behind storage drums in the center is the main group of vessels in the plant, the reactor-generator section, of which the spent catalyst stripper atop the reactor is visible.

This Hydroformer, the world's second, has a capacity of 12,780 barrels a day. It was designed and constructed by The M. W. Kellogg Company. Following this unit on stream will be a 17,250-barrel-a-day Hydroformer at the Cities Service refinery at Lake Charles, La.

Caltex Company Starts Major Refinery Expansion

Major expansion has started on the refinery of Raffineries de Petrole de la Gironde, an affiliated company of the Caltex Group, at Bec d'Ambes, France. To improve the quality of petroleum products, approximately $8,300,000 will be spent on a catalytic cracking unit, vacuum distillation unit, catalytic polymerization unit and general expansion of utility services.

The present refinery, at the junction of the Garonne and Dordogne Rivers 15 miles north of Bordeaux, was completed in 1950 on the site of a war-damaged refinery. The average daily run during 1954 was 20,000 barrels. Refined products are distributed from 13 bulk depots.

Texas Gulf Starts Up New West Texas Gas Plant

The new $1,750,000 gas plant of Texas Gulf Producing Company in the Headlee field in Ector County, Texas, has been put in operation. The plant is designed to process 15 Mmcf of casinghead gas a day.

When running at capacity, the plant will have a daily recovery of 1400 barrels of liquids. Texas Gulf expects the plant to reach capacity by next May. The company is considering expansion of the plant late next year to a capacity between 30 and 50 Mmcf of gas a day.

Planned Finland Refinery Center of Sharp Dispute

The proposed construction of a nationalized oil refinery in Finland has become the center of a lively dispute between government officials and western oil companies operating in Finland.

The western oil companies maintain they are prepared to withdraw from Finnish markets rather than distribute products of the state-owned refinery which will be built to process Soviet crude oil. These companies are already distributing Soviet products since 80 percent of Finland's present demand of nearly 20,000 barrels a day of petroleum is met by imports from the Soviet bloc.

Finnish officials have denied reports that plans for the oil refinery resulted from a Soviet "suggestion." A top official of the state-owned Neste Corporation, which will build the refinery, said Soviet offers of crude oil and an invitation to Finnish technicians to study Soviet refineries came after the announcement of the refinery plans. This official said bids for construction of the refinery have been received from American, British, German and French companies.

While the debate continued, the Finnish Parliament approved plans for the construction of the refinery. Finland's first, it will have a capacity of about 14,000 barrels a day. Parliament voted to approve a government guarantee of a foreign loan not to exceed $17.5 million required to finance

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Who's Building . . .

construction.

Neste Corporation and government officials insist that demand for petroleum products in Finland is growing so rapidly that the market remaining to private enterprise will be just as large after the completion of the refinery in 1956 as it is now.

California Standard Will Build Honolulu Refinery

Plans for the construction of the first complete modern oil refinery in the Hawaiian Islands have been announced by Standard Oil Company of California.

The announcement was made as members of Standard's board of directors met in Honolulu recently for the first time in the history of the company.

R. G. Follis, chairman of the board, said that the refinery will be built in the very near future and will be located in Honolulu.

"We have been trying for some time to find a site which will be suitable," he commented, "but have not yet made a decision as to its location. We must have a location with an ample supply of fresh water, one which is large enough to accommodate the necessary processing and storage facilities and which is accessible to both deep water ships and to other means of transportation.

"The refinery we have in mind will be of sufficient size to supply most of the needs of the Islands, capable of processing between 20,000 and 30,000 barrels of crude oil daily. We estimate that a plant of this size will cost between $25 and $30 million to build here."

Products which could be manufactured by the plant include two grades of gasolines, gas oils such as diesel fuel and fuel oil of the type burned in many of the Island's power generating plants.

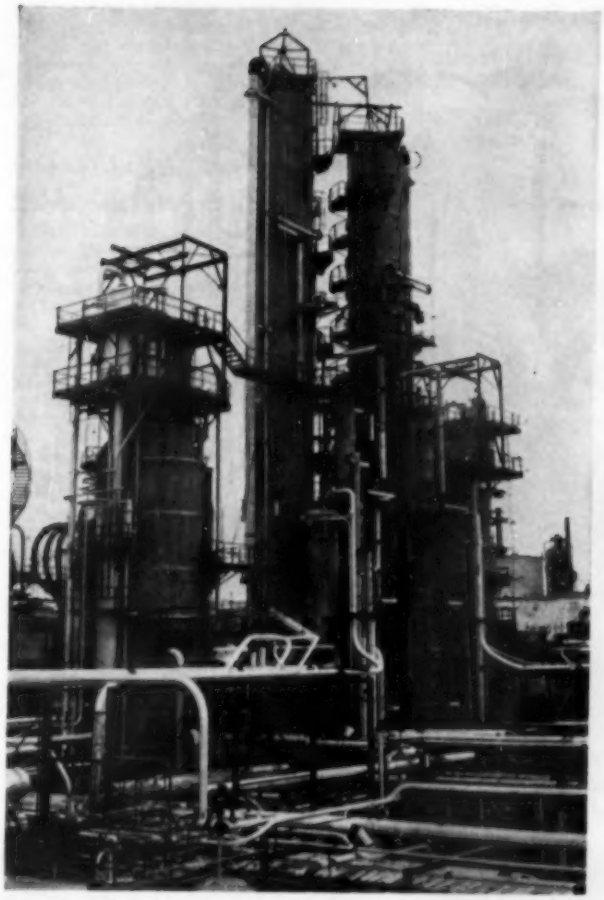
Crown Central Starts Up 5000-Barrel Houdriformer

A 5000-barrel-a-day Houdriformer has gone on stream at Crown Central Petroleum Corporation's refinery near Houston. Designed primarily for the up-grading of naphthas to produce high octane motor gasolines, the Houdriformer is also capable of producing aromatics and aviation blending stocks. Basic process designs for the new unit were furnished by Houdry Process Corporation. The western headquarters of Blaw-Knox Company handled over-all engineering and construction of the catalytic reformer and other facilities.

Indiana Standard Starts Operation of Ultraformer

A new 3750-barrel-a-day Ultraforming unit has been put into operation at the Casper, Wyo., refinery of Standard Oil Company (Indiana). The unit, second catalytic reforming unit of its type, was built by The Lummus Company.

The first Ultraformer went on stream last summer at Pan Am Southern Corporation's El Dorado, Ark., refinery. The largest such unit, a 21,000-barrel-a-day facility, is being built by Pan American Refining Corporation and will be completed early this year. Indiana Standard is building two 9000-barrel-a-day units, one at its refinery at Wood River, Ill.,



New Crude Distillation Towers at SOHIO's Cleveland No. 1 Refinery. These twin 3-stage units are 130 feet high, 13 feet O.D.; handle 22,500 bbl. per day each. Monel linings limit corrosion in upper sections. Fabrication by A. O. Smith Corp. Engineers and contractors, Arthur G. McKee & Company.

Why Sohio put Monel on Top..

when they picked materials to limit corrosion in new atmospheric towers

Slugs of crude get shunted around the country today, as if they were tank cars.

With so much crude moving in "common-carrier" pipelines...there's no telling from one day to the next what composition you may be called upon to refine.

SOHIO's Cleveland Number 1 Refinery draws its crudes, for example, from the Mid-Valley and Buckeye Lines . . . and taps output of wells in Arkansas, Illinois, Mississippi, Oklahoma, Texas and Louisiana. Most of the time sulfur content is under 1½%. Sometimes it goes much higher. Salt content, too, is unpredictable.

That's why SOHIO engineers went all out to limit corrosion in two new 130-ft. atmospheric towers for crude distillation. They lined the bottom 50 feet with Type 405 (12% Cr) to resist hot sulfide corrosion. In the middle sections, where naphthenic acids are likely, they put nickel-bearing Type 316 ELC stainless*.

For the top 40 feet, they chose Monel®. In this location they have found Monel to be the most economical material for the job.

There are several reasons for this. For one thing, Monel costs less per pound than other alloys able to withstand the corrosion. Furthermore, it requires no heat-treatment after fabrication to restore corrosion resistance, since its corrosion resistance is not impaired by welding. Then, too, Monel is easy to form . . . and lends itself well to Smithlining.

(Smithlining is the resistance welding process used by the tower fabricators, A.O.Smith Corp., to bond Monel and other liners to carbon steel walls.)

But the most important reason for choosing Monel is the way Monel stands up to the various corrosives found in upper sections of fractionators.

In this area, reflux pushes vapor temperatures down to about 250°F. Walls and trays cool vapors further. As they go below the dew point, aqueous hydrochloric and sulfuric acids form in the condensate. Corrosive salt compounds may be present also.

The record of Monel in resisting *all* these forms of corrosion, when temperatures are under 500°F., is outstanding . . . so outstanding that many companies consider Monel to be the standard construction material for lining top portions of fractionators.

If your next inspection shows corrosion at the tops of your crude distillation towers, why not investigate the use of Monel? A letter addressed to Inco's Corrosion Engineering Section will bring full information regarding the application of Monel in this corrosive service. No cost or obligation, of course.

*Where there is a possibility of naphthenic acid attack, either alone or combined with high temperature sulfur corrosion, *Inconel®* is often a favored material. Since its thermal expansion coefficient (6.4 for the wrought material) is very close to that of mild steel, Inconel lends itself unusually well to lined construction.

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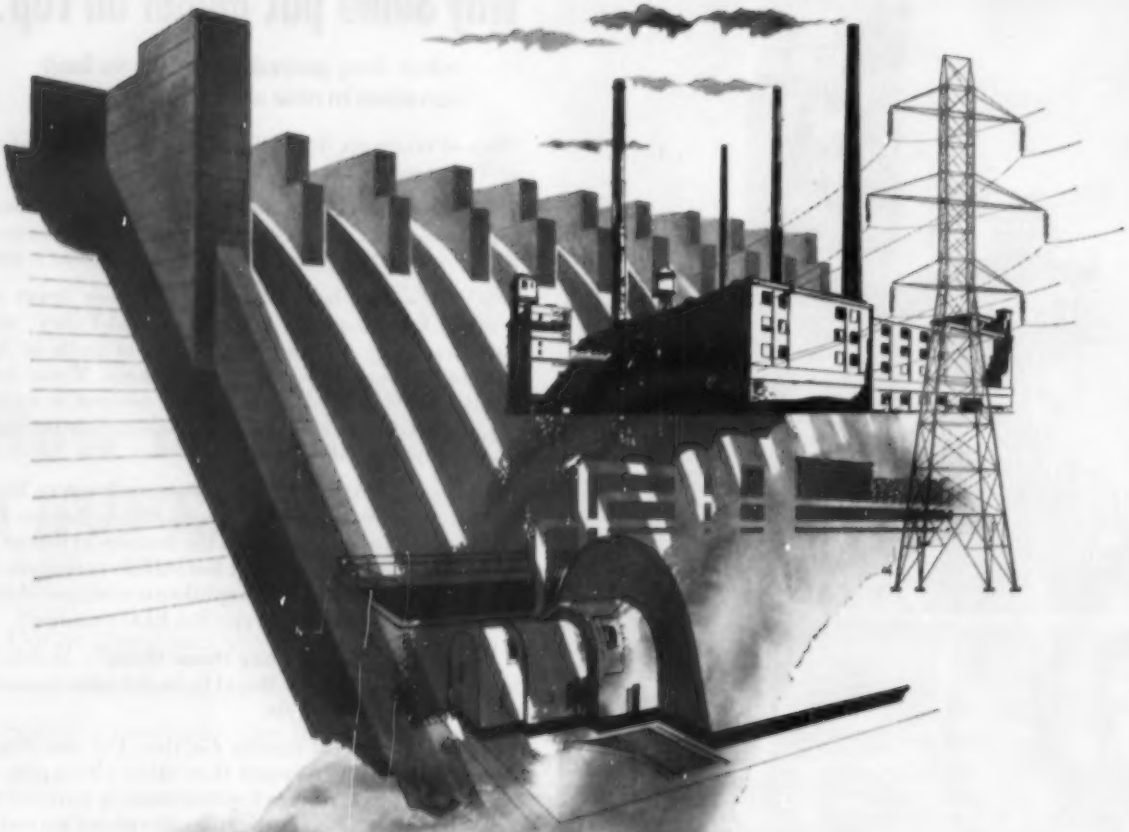

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and the other at Sugar Creek, Mo.

A small Ultraformer of the same size as the one completed at Casper is being considered for the new Mandan, N. D., refinery. Another is tentatively planned for the Salt Lake City refinery of Utah Oil Refining Company.

Assam Oil Completes New Lube Facility in India

New processing facilities have been put in operation in Assam, northeast India, by Assam Oil Company, Ltd. (Burmah Oil Company, Ltd.) They include a lubricating oil plant and an absorption gasoline plant.

Expansion and modernization of the plant followed the discovery of a new oil field at Nahorkatiya in 1953. The company's only other production comes from the Digboi field. The company has also increased the capacity of its Digboi refinery from about 5150 to 7150 barrels a day. Capacity is expected eventually to be raised to nearly 11,000 a day.

New and proposed expansions will enable Assam Oil to supply an estimated 10 percent of India's petroleum needs.

The new lube plant manufactures about 700 barrels of lubricants daily. The gasoline plant processes 9 Mmcf of gas per day and has a daily yield of about 1700 barrels of natural gasoline.

Price Settlement Starts Work on Lebanon Refinery

Construction of a refinery in Lebanon was stopped temporarily last month because of a price dispute between the Lebanese government and the American-owned Mediterranean Refining Company, which is building the installation.

Medreco, jointly owned by California Texas Company (Caltex) and Socony-Vacuum Oil Company, has the refinery nearing completion at Sidon, Lebanon. A spokesman for Caltex said negotiations with the Lebanese government over prospective prices of the refinery's products broke off some time ago.

Speaking early in the month, he added that he hoped they would be resumed soon. And by month's end, negotiations had been resumed and agreement reached on prices. Work was then resumed with completion and startup of the plant expected in about four weeks.

With settlement of the price dispute, Medreco announced it had added to its plans an increase in the capacity of the crude oil unit and the addition of a second platformer, increasing the refinery capacity from 6000 to 9000 barrels of crude oil daily. The added expansion will bring the total investment from $6 million to $8 million. The new projects are to be completed in 1956.

Shell Starts Up Third UOP Platforming Unit

The third UOP Platforming unit built for Shell Oil Company has gone into operation at the Shell Wood River, Ill., refinery. The 16,000-barrel-a-day unit is processing naphtha derived from mixed crudes.

A 5000-barrel-a-day Platformer is in operation for Shell at Martinez, Calif., and another 16,000-barrel-a-day unit at Houston. All were designed, engineered and licensed by Universal Oil Products Company. Procon Inc., was the contractor on the Wood River and Houston projects.

Petrofina Erecting Canada's Tallest Cat Cracker Tower

Guy derrick being used to erect Houdriflow cat cracker.

The tallest Houdriflow catalytic cracking tower ever built in Canada is now being erected at the Canadian Petrofina, Ltd., refinery being constructed in Montreal.

Canadian Vickers, Ltd., is building and erecting the Houdriflow unit for The Lummus Company, Canada, Ltd., general contractors for the plant. When completed, it will be 285 feet high with a maximum diameter of 24 feet. The tower is being shop-fabricated in 16 sections which are being trucked to the plant site.

To lift the sections in place, the highest guy derrick ever used on this continent has been erected at Pointe Aux Trembles. The derrick has an overall height of 425 feet. The mast, 215 feet high, and boom pivot on a tower of open girder construction 210 feet high and 84 inches square. Developed by the West German firm of Man for another Lummus Houdriflow unit built at Lingen, Germany, the derrick was brought to Canada by Canadian Vickers, Ltd., for this job.

As now assembled the derrick can lift 80 tons a height of 400 feet. Heaviest lift on the Petrofina job is 76 tons. The derrick is guyed to four concrete anchors, 17-foot square and imbedded deep in the earth. A tension of ten tons is maintained on each guy by means of three winches tied into each deadman.

At the Petrofina refinery, work is well under way on the refinery gas plant and the hydrodesulfurization unit. Completion of all work is scheduled for mid-1955.

Who's Building . . .

Construction Capsules

Grace Chemical Company has started operation of its $20 million ammonia-urea plant at Memphis, Tenn. The plant will have a rated capacity for producing 250 tons a day of synthetic anhydrous ammonia, part of which will be converted into 150 tons per day of urea.

Westvaco Chlor-Alkali division of Food Machinery and Chemical Corporation has awarded a contract to The Lummus Company for the construction of a 60-ton-a-day anhydrous ammonia plant at South Charleston, W. Va. Construction is already underway on the project, which is to be completed in late 1955.

E. I. du Pont de Nemours & Company, Inc., plans to construct a neoprene plant at Montague, Mich. The plant is expected to be completed by the fourth quarter of 1956.

Clark Oil and Refining Corporation has started operation of a new 5500-barrel-a-day UOP Platforming unit at its Blue Island, Ill., refinery, in the Chicago area. Universal Oil Products Company designed, engineered and licensed the Platformer. Procon Inc. was the contractor on the project.

Naph-Sol Refining Company has begun operation of a new UOP Platforming unit at its refinery at Muskegon, Mich. The 1000-barrel-a-day unit, seventh of its kind in Michigan, is designed to make 95 leaded octane Platformate from a charge stock of naphtha which is derived mainly from West Texas crudes. Universal Oil Products Company designed, engineered and licensed the unit.

Sinclair Refining Company has awarded a contract for the construction of an extension to its demulsifying plant at Sand Springs, Okla., to Tuloma Builders, Inc.

Nitrogen division of Allied Chemical & Dye Corporation has completed construction of a new ethanolamine unit at its Orange, Texas, petrochemical plant. Commercial production of monoethanolamine, diethanolamine and triethanolamine is expected to start this month. Austin Company of Houston built the unit.

Standard Oil Company of Texas has awarded a contract to Bechtel Corporation for the construction of a 4500-barrel-a-day catalytic reformer at its El Paso, Texas, refinery. The unit was designed by California Research Corporation, subsidiary of Standard Oil Company of California. The unit is expected to be completed by August, 1955.

Texas Eastman Company has begun production of polyethylene plastic at a new plant at Longview, Texas. The plant has a capacity of 20 million pounds a year.

United Gas Pipe Line Company expects to complete the 100 Mmcf gasoline plant it is building near Runge, Texas, this month. Operating at maximum capacity, the plant will be able to recover approximately 70,000 gallons of liquid products a day while upgrading the quality of the gas itself. Construction was handled by Fish Engineering Corporation.

The Ohio Oil Company has completed construction of a new natural gasoline plant in West Sidney Field, Nebraska. The plant has a capacity to process 12 Mmcf of gas a day.

Sioux Oil Company plans to enlarge its two refineries at Newcastle, Wyo., under

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Manager

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4. FURTHER RESEARCH. Now under consideration and development are several new materials from which National Sections may be cast, in addition to currently available close grained gray cast iron and chrome nickel iron. These developments will be of particular interest in connection with the handling of flammable fluids. Further announcements in this field will be forthcoming soon.

These new developments plus the fact that National Cooling and Condensing Sections are performing in many industrial, chemical and oil field and refining applications with high efficiency and with minimum maintenance prove that it pays to consult with National about your cooling and condensing problems. Write for our latest Bulletin CEC-54

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Who's Building . . .

a $4 million expansion and development program which also includes the construction of a 55-mile products pipe line to Rapid City, S. Dak. The two refineries, which now have a total capacity of 4000 barrels a day, will be expanded to 5000-barrel-a-day capacity.

British American Oil Company has awarded a contract to Lummus Company of Canada, Ltd., for the construction of a $3 million catalytic reformer at British American's Montreal East refinery. The unit will process about 13,000 barrels a day of straight run naphtha. The unit is scheduled for completion in late 1955.

Esso Refinadora Petroleo S. A. has been authorized by the Argentine government to install a high grade solvent extraction lubricating oil plant with an annual capacity of about 375,000 barrels. The plant would eliminate the use of sulfuric acid utilized in the present Esso refinery, and would greatly reduce present imports of basic lube oil. Its production would represent approximately $8 million in yearly saving in foreign exchange.

Yacimientos Petroliferos Fiscales (ENDE), Argentine government oil agency, has completed expansion of the capacity of its oil refinery at Mendoza. The expansion increased production over 130 percent, to 11,000 barrels a day of crude oil. Concurrently, Y.P.F. completed construction on its 28,300-barrel-a-day Eva Peron refinery. The M. W. Kellogg Company handled construction on the latter project.

Capuava oil refinery in Sao Paulo, Brazil, has been dedicated. The refinery, constructed in 14 months, has a capacity of 20,000 barrels a day and is the second refinery opened within two weeks in that area. The first was the Manguinhos refinery, also of Sao Paulo, which has a capacity of 10,000 barrels a day. Hydrocarbon Research Company was in charge of the Capuava project, which is owned by private capital. Construction of the $12 million Refinaria de Petroleos de Manguinhos S/A refinery, which included thermal cracking and visbreaking facilities, was handled by Kellogg Pan America.

Helios, S.A., which plans to build an oil refinery at San Andres, near Port of Pisco, Peru, has expanded its plans to include a fertilizer plant to produce 130,000 tons a year of ammonium nitrate from refinery gases. Crude oil for the refinery will be supplied by Empresa Petrolera Fiscal, a government petroleum agency.

Corporacion General de Petroleo and Refineria Cabaiguan will build a new 1000-barrel-a-day refinery for processing asphaltic base crude near Havana, Cuba. Kerr-McGee Industries will assist.

Johnson Line, Stockholm shipping company, reportedly plans to build an oil refinery at Gothenburg, Sweden. In its first stage, the refinery will process about 2500 barrels a day. It will include atmospheric and vacuum distillation units, an oxidation plant for the production of asphalt, blending plants and storage.

Iraq Development Board will study a proposal to build a plant near the present Dora refinery to produce asphalt from oil used by the refinery and a projected lubri-

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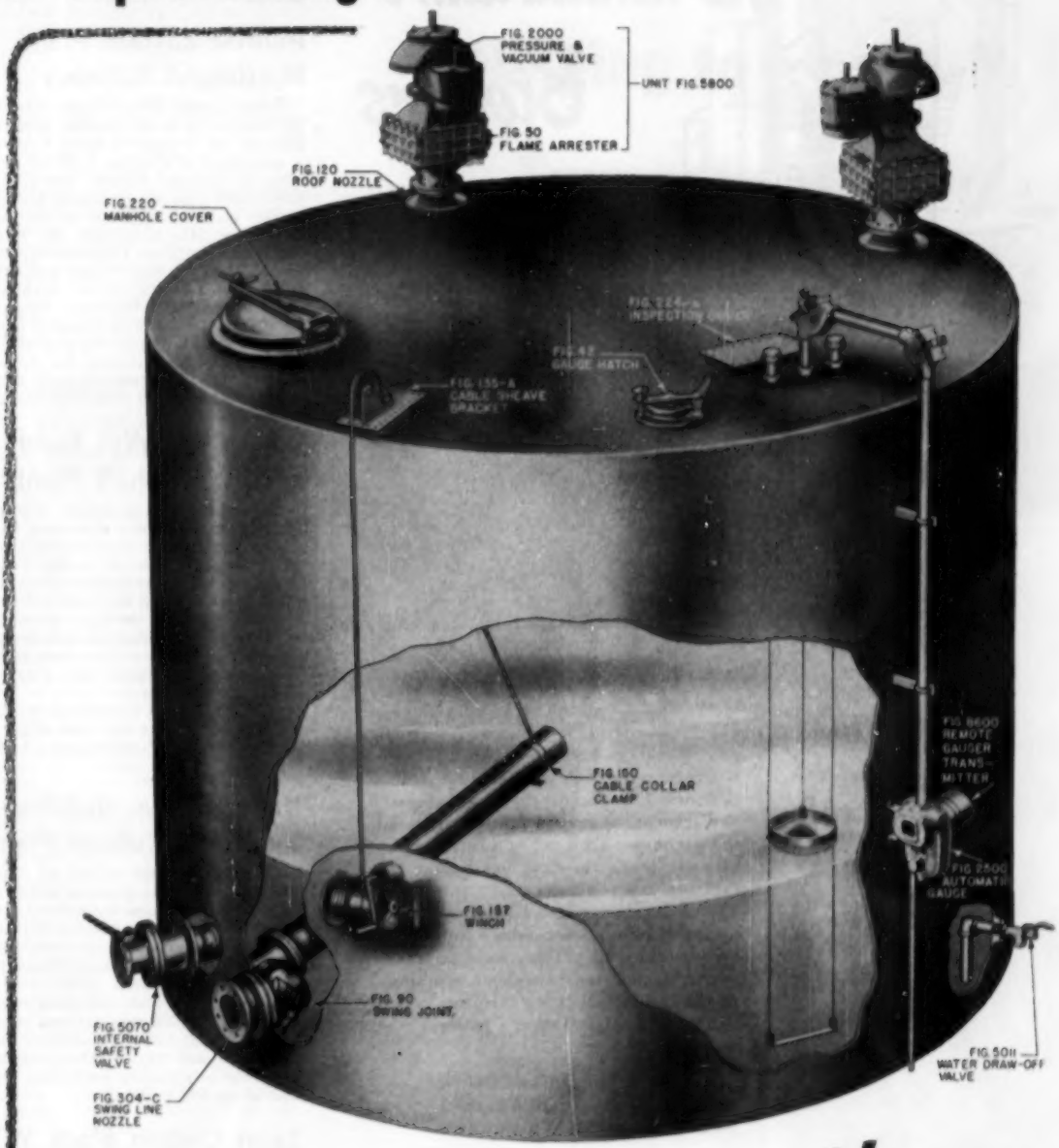
FIG. 2000 PRESSURE & VACUUM VALVE
UNIT FIG. 5800
FIG. 50 FLAME ARRESTER
FIG. 120 ROOF NOZZLE
FIG. 220 MANHOLE COVER
FIG. 42 GAUGE HATCH
FIG. 155-A CABLE SHEAVE BRACKET
FIG. 8600 REMOTE GAUGER TRANSMITTER
FIG. 150 CABLE COLLAR CLAMP
FIG. 2500 AUTOMATIC GAUGE
FIG. 187 WINCH
FIG. 90 SWING JOINT
FIG. 5070 INTERNAL SAFETY VALVE
FIG. 304-C SWING LINE NOZZLE
FIG. 501 WATER DRAW-OFF VALVE

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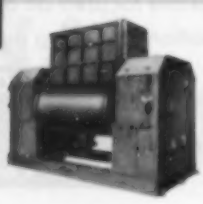

Who's Building...

cating plant to be built on the same site. At the same time, the board will consider another proposal to produce sulfur from oil at the Dora and Qayara refineries.

Pontiac Eastern Plans Mississippi Refinery

Construction of a 12,000-barrel-a-day oil refinery in South Central Mississippi is planned by Pontiac Eastern Corporation, a subsidiary of Pontiac Refining Corporation, of Corpus Christi, Texas. The refinery will cost an estimated $10 million.

The installation would be the third refinery for Mississippi and the largest in the state. The Fluor Corporation, Ltd., has the contract for engineering and designing work. The site has not yet been selected.

For some time, Governor Hugh White of Mississippi has been trying to get a new refinery for the state. He had asked Gulf Oil Corporation officials for help. Gulf, uninterested in the project itself, persuaded Pontiac Refining to undertake the project.

ARAMCO Will Build Second Asphalt Plant

Because of the increased requirements for its asphalt, Arabia American Oil Company is planning the construction of a second asphalt plant at its Ras Tanura refinery. The present asphalt plant, built in 1950, was designed to produce 500 barrels per day; however, through operational improvements, the plant can now average 800 barrels per day. The new plant, to be completed in 1956, would have a capacity of 1250 barrels per day.

ARAMCO now not only uses asphalt in its own operations but also ships a large part of its Ras Tanura output to western Saudi Arabia.

Italian Group Building Synthetic Rubber Plant

Construction has started on a plant at Ravenna, Italy, to produce synthetic rubber and nitrogeneous fertilizers from methane gas. Erecting the plant is ANIC, which belongs to a group of oil companies controlled by the Italian government's Ente Nazionale Idrocarburi (ENI).

Within three years the plant is expected to produce 30,000 tons per year of synthetic rubber and 350,000 tons of fertilizers, consuming about 14,000 Mmcf of methane gas from neighboring wells. The plant will cost about $75 million.

Lynn Carbon Black Will Build Experimental Unit

Construction of a full-scale carbon black plant in the San Angelo, Texas, area is planned by Lynn Carbon Black Company for purposes of research and development.

The plant will use the Lynn "Furmatic" process, according to Rice P. Lynn, president of Lynn Carbon Black and inventor of the process.

A decision is expected soon as to the exact location and capacity of the experimental plant. Output of the plant, which will be operated in conjunction with Lynn's product research efforts, will go to a new fertilizer plant which is being built

Who's Building. . .

by Consolidated Carbon Corporation in Chicago. Lynn Carbon Black recently sold Consolidated Carbon world rights to manufacture carbon black by the Lynn method but retained the right to build an experimental plant.

Consolidated Carbon, Lynn said, has located sites for five new carbon black plants which will use his process. The decision as to when construction will start is expected this month. Two of the plants will be located in Louisiana, and one each in North Dakota, Wyoming and Canada.

The contract between Consolidated Carbon and Lynn called for the construction by Consolidated Carbon of one new plant a year for ten years. The first was to have a gas-processing capacity of 2.5 Mmcf a day and the remainder to have a minimum capacity of 5 Mmcf a day. Design of the plants is to be handled by Dr. W. H. Balka, Dallas consulting engineer and vice president of Lynn Carbon Black.

Cities Service Heads ODM Write-Off Approvals

Largest project approved for rapid tax write-off by the Office of Defense Mobilization during the last month was Cities Service Oil Company's proposed construction of a natural gasoline plant in Midland County, Texas. The installation is to process 45 Mmcf a day of natural gas into LPG products and natural gasoline.

Cities Service was allowed to write-off at the fast rate 65 percent of $5,534,200 for the general plant, 65 percent of $471,000 for storage and 40 percent of $831,800 for gas gathering facilities.

Other refining and related projects approved for fast tax amortization on the latest ODM list, including company, location, facilities, amount certified, and percentage certified, were:

Goliad Corporation—San Patricio County, Texas, natural gasoline plant to process 188 Mmcf a day of natural gas into LPG products, $3,994,750: $3,909,750 at 65 percent, and $85,000 at 25 percent.

Sinclair Refining Company—East Chicago, Ind., expansion and revision of a catalytic cracking unit and gas plant, $3,252,000: $2,255,405 at 60 percent, and $996,595 at 50 percent.

Frontier Refining Company—Cheyenne, Wyo., addition of 2000-barrel-a-day catalytic reforming unit, 3000-barrel-a-day desulfurizing unit, six storage tanks and auxiliary facilities, $1,500,000: $1,100,000 for basic equipment at 65 percent, and $400,000 for auxiliary facilities at 45 percent.

Magnolia Petroleum Company—Midland County, Texas, construction of compressor station, gathering system, transmission line and gas lift facilities to provide casinghead gas to Pegasus natural gasoline plant, $1,366,800: $825,800 for the general plant work at 65 percent, and $541,000 for gas gathering at 40 percent.

Honolulu Oil Corporation—Nolan County, Texas, construction of gas gathering system and natural gasoline plant to process 6.5 Mmcf a day of natural gas and produce 1210 barrels a day of LPG products, $1,097,000: $957,000 at 65 percent, and $140,000 at 40 percent.

Fletcher Oil Company—Wilmington, Calif., construction of a 10,000-barrel-a-day crude oil topping unit and auxiliary facilities at its refinery, $976,000: $415,000 for basic facilities at 65 percent, and $561,-

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Who's Building . . .

000 for auxiliary facilities at 40 percent.

Esso Standard Oil Company—Everett, Mass., installation of two 25,000-barrel-a-day desalters for crude topping units at its refinery, $612,000: $367,000 for basic units at 65 percent, and $245,000 for auxiliaries at 40 precent.

Phillips Petroleum Company—Phillips, Texas, development of three 110,000-barrel capacity underground caverns for propane storage, including installation of dehydration facilities, $356,750 at 40 percent.

Stanolind Oil & Gas Company—Ector County, Texas, installation of 1600 h.p. gas compressor and auxiliary facilities in North Cowden natural gasoline plant, $209,000 at 65 percent.

Venezuela Considering Petrochemical Plants

Venezuela is reportedly moving to halt the flaring of natural gas in its oil fields with the construction of petrochemical plants designed to utilize the gas. The plants are projected for eastern Venezuela, between Puerto La Cruz and Anaco.

The selected site would be near the Caroni River hydroelectric project and a multimillion dollar steel plant expected to be built a short distance to the south in the State of Bolivar. Both projects are near the iron ore operations of United States Steel Corporation and Bethlehem Steel Corporation.

SASOL Starts Up Oil-From-Coal Plant

South Africa Coal, Oil & Gas Corporation, Ltd., has begun operations of its big plant at Coalbrook, Union of South Africa, which is designed to synthesize liquid hydrocarbons and chemicals from coal.

The installation, located about 50 miles from Johannesburg, includes facilities for everything from coal mining to fractionation of the final products. It was built with government financing and cost an estimated $92 million. Full production of the plant is expected to be reached near the end of this year but some products are already on the market.

The SASOL oil-from-coal plant utilizes improved versions of the original Fischer-Tropsch process. Licenses for the German process were acquired from Ruhr-Chemie, A. G., and associates, and those for the American process from The M. W. Kellogg Corporation. Both processes were combined by SASOL in one integrated plant suited to local conditions.

Kellogg designed and engineered many of the individual process units. Its subsidiary, Kellogg International Corporation, had charge of over-all procurement and construction.

Anglo-Iranian on Stream With Two New Platformers

The first two of six UOP Platforming units being built for the Anglo-Iranian Oil Company group (now British Petroleum) were recently commissioned in widely separated parts of the world.

One—the first in the Middle East—is at Anglo-Iranian's new $126 million refinery at Aden on the Arabian peninsula near the entrance to the Red Sea. This unit processes 12,000 barrels a day of naphthas from Middle East crude oil to produce high grade gasoline blending component.

The second unit, at the BP Benzin-und Petroleum B.M.B.H. refinery at Hamburg, Germany, has a capacity of 6000 barrels a day.

Platforming units are also being built for Anglo-Iranian at Llandarcy, Wales; Kent, England; Lavera, France, and Kwinana, Australia. All are designed, engineered and licensed by Universal Oil Products Company.

Chile Produces Gasoline

The first gasoline produced in Chile has been turned out at the new 25,000-barrel-a-day refinery of Empresa Nacional de Petroleo, 20 miles north of Valparaiso. Besides 12,000 metric tons of gasoline, the refinery has also produced 1000 tons of kerosine and 5000 tons of diesel oil.

Construction Boxscore: Refineries and Other Plants . . .

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
EAST									
Allied Chem. & Dye Corp.	Hopewell, Va.	Inc. Ammonia Capacity	50,000 tons/yr.			1955		Girdler	Girdler
Allied Chem. & Dye	Buffalo, N.Y.	Aromatic Fac.		$6,940,000	PAD Certified				
American Oil Co.	Yorktown, Va.	Refinery	35,000 bbls.	$25,000,000	Clearing Site	Spring, 1956			
Ashland Oil & Refining Co.	Catlettsburg, Ky.	Houdriformer	6,000 bbls.		Under Constr.	June, 1955	Houdry	Cat. Constr.	Cat. Constr.
Du Pont	Louisville, Ky.	"Freon-22"			Under Constr.	4th Qtr., 1955			
Esso Standard Oil Co.	Baltimore, Md.	Fixed Bed Hydroformer	3,000 bbls.		Under Constr.	2nd Qtr., 1955		SOD & Contractor	Foster Wheeler
Esso Standard Oil Co.	Baltimore, Md.	Hydrofinishing Equip.	17,000 bbls.		Under Constr.	2nd Qtr., 1955		SOD & Contractor	Foster Wheeler
Esso Standard Oil Co.	Baltimore, Md.	Fluid Coker	10,000 bbls.		Under Constr.	2nd Qtr., 1955		SOD & Contractor	Bechtel
Esso Standard	Linden, N.J.	Cat. Poly. Plt.	9,100 bbls.		Under Constr.	1st Qtr., 1955		S.O.D., Braun	Braun
Esso Standard	Everett, Mass.	Asphalt Vacuum Tower	13,100 bbls.		Complete		S.O.D.	S.O.D.	
The Girdler Co.	Louisville, Ky.	Catalyst Plt.			Complete			Girdler	Girdler
B. F. Goodrich Chemical Co.	Calvert City, Ky.	Chemical Plt.		$8,600,000	Under Constr.	March, 1955		Fluor	Fluor
*B. F. Goodrich	Shelton, Conn.	Carbon Dioxide Plt.	25 tons		Engineering	July, 1955		Girdler	Girdler
*Gulf Chemical Co. (United Gas & Others)	Pensacola, Fla. Vicinity	Anhydrous Ammonia							
		Polyvinyl Chloride			Planned				
Gulf Oil Corp.	Philadelphia	Sulfur Recovery		$1,100,000	Under Constr.	2nd Qtr., 1955		Parsons	Parsons
Hercules Powder Co.	Burlington, N.J.	Dimethyl Terephthalate Plt.			Under Constr.	March, 1955			
*Ketona Chemical Corp. (Owned by Alabama By-Products & Hercules Powder)	Ketona, Ala.	Anhydrous Ammonia Plt.	45,000 tons/yr.		Planned	Late 1955		Fluor	Fluor
Monsanto Chemical Co.	Springfield, Mass.	Styrene Compounding		$3,400,000	Under Constr.	1st Qtr., 1955		Monsanto	Adams & Ruxton
Monsanto Chemical Co.	Springfield, Mass.	Research Fac.		$1,000,000	Under Constr.	1st Qtr., 1955		Monsanto	D. O'Connel
Northern Chemical Industries	Searsport, Maine	Ammonia	125 tons		Engineering		Texaco	Girdler	Girdler
		Nitric Acid	60 tons	$7,500,000	Engineering		Du Pont	Girdler	Girdler
		Nitrogen Solutions			Engineering			Girdler	Girdler
Sinclair Refining Co.	Marcus Hook, Pa.	Para-Xylene Plt.	10 mln. lbs./yr.	$2,200,000	Under Constr.	1st Qtr., 1955		Badger	Badger
*Socony-Vacuum Oil Co.	Paulsboro, N.J.	Sova former Unit	20,000 bbls.		Under Constr.	July, 1955	Soc.-Vac.	Fluor	Fluor
Sun Oil Company	Marcus Hook, Pa.	Houdriflow Cat. Crker.	27,000 bbls.	$7,500,000	Under Constr.	March, 1955	Houdry	Houdry, Cat. Constr., Sun	Cat. Constr.
Sun Oil Company	Marcus Hook, Pa.	Houdriformer Cat. Unit	18,000 bbls.	$4,500,000	Under Constr.	April, 1955	Houdry	Sun, Houdry	Cat. Constr. Su
Sun Oil Company	Marcus Hook, Pa.	Vacuum Unit	22,000 bbls.	$1,500,000	Design	March, 1955		Sun, Cat. Constr.	Cat. Constr.
*Sun Oil Co.	Marcus Hook, Pa.	Anhydrous Ammonia Plt.	300 tons	$9,000,000	Under Constr.	Nov., 1955		Cat. Constr.	Cat. Constr.

• Construction Boxscore continued on page 189

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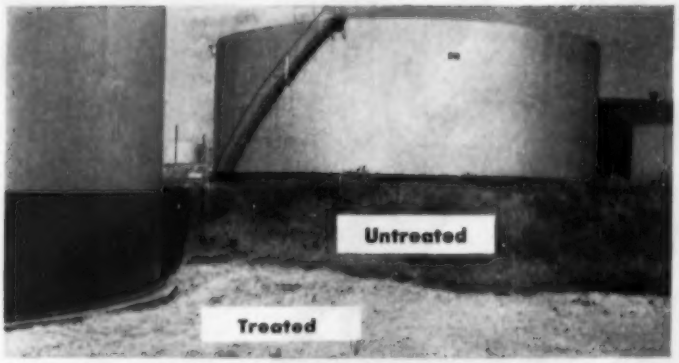

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"Ammate" kills more kinds of brush and keeps it down longer than most weed and brush killers!

When the original spray job is well done, brush is kept under control with nothing more than an occasional spot spray later. You can rely on "Ammate" to do the job safely, even where your rights-of-way adjoin crop land, because "Ammate" is not volatile. There are no vapors to drift onto sensitive crops.

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REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

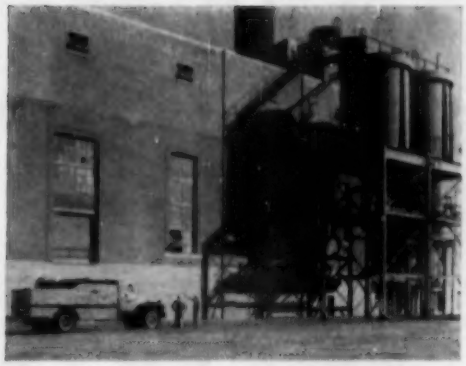
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
Texas Company	Westville, N.J.	Cat. Reforming	12,000 bbls.		Under Constr.	1st Qtr., 1955		U.O.P., Procon Staff	Procon, Other.
Texas Company	Westville, N.J.	Alkylation Fac.	1,850 bbls.		Under Constr.	1st Qtr., 1955		Staff	Cat. Constr., Others
The Texas Company	Westville, N.J.	Platformer	12,000 bbls.		Complete		U.O.P.	Procon	Procon
Tide Water Associated Oil	Eastern Seaboard	Refinery	100-130,000 bbls.	$100,000,000	Planning			Braun	
Union Carbide & Carbon Corp.	Leakville, N.C.	Dynel Fiber Plt.		$30,000,000	Planning	1955		Staff	
MID-CONTINENT									
Allied Chemical & Dye	Cleveland, Ohio	Chemical Plt.		$2,000,000	Complete			Staff	M-C & S.
Amerada Pet. Corp.	Williston Basin, N.D.	Natural Gasoline Plt.		$10,000,000	Planning				
*Atlas Powder Co.	Site Undetermined	Anhydrous Ammonia Plt.		$6,750,000	ODM Certifed				
*Atlas Powder Co.	Site Undetermined	Glycerin Plt.		$5,940,000	ODM Certified				
Aurora Gasoline	Detroit, Mich.	Basic Refining		$400,000	Announced				
Bay Refining Corp.	Bay City, Mich.	Cat. Cracker	6,000 bbls.	$3,000,000	Complete		Soc.-Vac., U.O.P.	Sweco	Sweco
		Cat. Poly Auxiliary Equipment	300 bbls.						
The Carter Oil Co.	Billings, Mont.	Fluid Coking Unit	3,800 bbls.		Complete		Std. Oil Dev. Co.	Fluor	Fluor
Central Petroleum Co.	Coyle, Okla.	Gasoline Plt.			Authorized				
Champlin Refining Co.	Enid, Okla.	Expansion:							
		Fluid Cat. Crker.	9,000 bbls.	$4,000,000	Planned	Nov., 1955	Kellogg		Kellogg
		Platformer	5,000 bbls.		Planned	May, 1955	U.O.P.		Sweco
*Commercial Solvents Corp.	Peoria, Ill.	Enlarge Nitroparaffin Derivatives Fac.			Planned				
Derby Oil	Wichita, Kans.	Platforming Unit		$2,700,000	Under Constr.				
*Du Pont	Montague, Mich.	Neoprene Plt.			Planned	4th Qtr., 1956			
Great Northern Oil Company	Pine Bend, St. Paul, Minn.	Crude Topping	25,000 bbls.					Fluor	Fluor
		TCC Unit	12,000 bbls.				Soc-Vac.	Fluor	Fluor
		Ultraformer	5,000 bbls.				Indiana-Standard	Fluor	Fluor
		Hydrodesulfurizer	11,000 bbls.	$20,000,000	Under Constr.	3rd Qtr., 1955	Indiana-Standard	Fluor	Fluor
		Cat. Poly.	900 bbls.				U.O.P.	Fluor	Fluor
		Delayed Coker	450 tons					Fluor	Fluor
*Great Plains Refinery Development Co.	Rapid City, S.D.	Refinery	3,000 bbls.	$3,000,000	Planned				
Gulf Oil Corp.	Toledo, Ohio	Refinery Fac.; Platformer	10,000 bbls.		Under Constr.	Early, 1955	U.O.P.	Procon	Procon
Gulf Oil Corp.	Cincinnati, Ohio	Platforming Unit & Aux. Units	70,000 bbls.		Under Constr.	April, 1955	U.O.P.	Procon	Procon
Hercules Powder Co.	Birmingham, Ala.	Anhydrous Ammonia Plt.	45,000 tons/yr.		Planning	1955			
International Refineries	Wrenchall, Minn.	Petroleum Refining Fac.		$9,500,000	ODM Approved				
Kerr-McKee Industries, Inc.	Wynnewood, Okla.	Fluid Type Cat. Crker, Gas. Plt. & Cat. Poly. Unit	6,000 bbls. of Fresh Gas-Oil Feed	$2,500,000	Complete		U.O.P.	Treco	Treco
Kerr-McGee Industries, Inc.	Wynnewood, Okla.	Offsite Fac.		$1,500,000	Complete			Koch, Others	
Mid-Continent Petroleum Corp.	W. Tulsa, Okla.	Inc. in Alkylation Cap.	1800 bbls.		Complete				
Mid-Continent Petroleum Corp.	West Tulsa, Okla.	Delayed Coking	7,000 bbls.	$2,300,000	Engineering	Dec., 1955		Kellogg	Kellogg
*Mid-West Refineries, Inc.	Alma, Mich.	Hydrogenation Unit & Related Fac.	2,500 bbls.	$368,000	Engineering				
Mississippi Chemical	Yazoo City, Miss.	Ammonia Plt.	120 tons	$2,000,000	Under Constr.	Feb., 1955	L'Air Liquide	Girdler, MCC Staff	Girdler, MCC Staff
Mississippi River Fuel Corp.	Crystal City, Mo.	Petrochem. Plt. Ammonia & Nitrates	200 tons	$15,000,000	Under Constr.	Oct., 1955	Texaco Dev.	Fluor	Fluor
Missouri Farmers Association	Joplin, Mo.	Fertilizer Plt.	220 tons	$3,500,000	Complete			Dorr Co.	M-C & S.
Naph-Sol Refining Co.	Muskegon, Mich.	Cat. Reformer	6,000 bbls.		Planned				
National Distillers Products	Tuscola, Ill.	Synthetic Ammonia Plt.	20,000 tons/yr.	$7,000,000	Complete			Kellogg	Kellogg
National Petro-Chemicals	Tuscola, Ill.	Polyethylene Facilities	25 million lbs./year		Under Constr.	Spring, 1955	I.C.I.	Kellogg	Kellogg
*Northwestern Refining Co.	St. Paul Park, Minn.	Gas Concentration Unit			Under Constr.	April, 1955			
Pana Refining Co.	Pana, Ill.	Modernization	11,600 bbls.	$900,000					
Pana Refining	Pana, Ill.	Girbotol Unit			Under Constr.				Parker
*Pontiac Eastern Corp.	South Central, Miss.	Refinery	12,000 bbls.	$10,000,000	Planned				Fluor
Prime Oil Co.	Calumet City, Ill.	Refinery	15,000 bbls.	$10,000,000	Planned				
Shell Oil Co.	Wood River, Ill.	Offsite Fac.			Complete			Fluor	Fluor
Shell Oil	Wood River, Ill.	Expansion and Improvement	180,000 bbls.	$42,800,000	Complete			Shell	Foster Wheeler, Fluor & McKee
Sinclair Refining	E. Chicago, Ind.	Barrel House Fac.		$2,700,000	Under Constr.	Summer, 1955		Sumner Sollitt	Sumner Sollitt
Sinclair Refining	E. Chicago, Ind.	Power Plt. Addi.		$870,000	Complete			Staff	Staff
Sinclair Refining	E. Chicago, Ind.	Gaso. Fract. Unit	20,000 bbls.	$1,300,000	Complete			Graver	Graver
Sinclair Refining Co.	E. Chicago, Ind.	Cat. Reformer	16,000 bbls.	$13,000,000	Under Constr.	Spring, 1955			Braun
Skelly Oil Co.	El Dorado, Kan.	Cat. Reformer	7,500 bbls.		Complete		U.O.P.	Skelly	Skelly
Standard-Indiana	Wood River, Ill.	Ultraformer	6,000 bbls.		Complete			Kellogg	Kellogg
Standard-Indiana	Mandan, N.D.	New Crude Ref.	30,000 bbls.		Complete				Lummus
Standard-Indiana	Whiting, Ind.	Fluid Hydroformer	27,000 bbls.		Under Constr.	Early, 1955		Kellogg	Kellogg
Standard-Indiana	Whiting, Ind.	Motor Oil Exp.	21,000 gals.		Complete				
Standard-Indiana	Whiting, Ind.	Crude Unit	55,000 bbls.		Planning	Early, 1956			Baran
Standard-Indiana	Wood River, Ill.	Coking Unit	7,000 bbls.		Planning	1957			
Standard-Indiana	Mandan, N.D.	Ultraformer	2,375 bbls.		Planning	Late 1956			
Standard-Indiana	Sugar Creek, Mo.	Ultraformer	12,600 bbls.		Engineering	Mid-Aug., 1955			Parsons
Standard-Indiana	Whiting, Ind.	Heavy Oils Modern.			Engineering	Early, 1956			Foster Wheeler
Standard-Indiana & Sinclair	Hammond, Ind.	Anhydrous Ammonia	300 tons		Planned	Early, 1956			
Standard Oil of N.D.	Grand Forks, N.D.	Refinery	2,000-2,500 bbls.		Planning				

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard Oil Company (Ohio)	Lima, Ohio	Petrochemical Plt: Anhydrous Ammonia Nitric Acid Nitrogen Solution Offsite Fac.	300 tons 60 tons 200 tons	$17,000,000	Under Constr.	Nov., 1955			Kellogg
Standard, Ohio		Urea Plt.	120 tons		Under Constr.	Late 1955	Vulcan	Vulcan Engr. Div.	McKee McKee
Sun Oil Co	Toledo, Ohio	Houdriflow Cat. Crker.	27,000 bbls.	$6,000,000	Under Constr.	Feb., 1955	Houdry	Houdry, Cat. Constr., Sun	Cat. Constr.
The Texas Co.	Lawrenceville, Ill.	Cat. Reformer	13,631 bbls.		Under Constr.	2nd Qtr., 1955		U.O.P.	Lummus, Others
The Texas Co.	Lawrenceville, Ill.	Alkylation Unit	2,253 bbls.		Under Constr.	2nd Qtr., 1955		Lummus, Others	
The Texas Co.	Tulsa, Okla.	Platform. Unit	9,040 bbls.		Under Constr.	3rd Qtr., 1955			
The Texas Co.	Lockport, Ill.	Platformer	16,854 bbls.		Under Constr.	3rd Qtr., 1955		Staff, U.O.P. and McKee	McKee
The Texas Co.	Lockport, Ill.	Alkylation Plt.	1,000 bbls.		Under Constr.	3rd Qtr., 1955		Staff	
Vulcan Asphalt Refining Co.	Cordova, Ala.	Relocation of Refinery	2,200 bbls.	$122,700	ODM Approved				
Warren Petroleum Corp.	Lindsay, Okla.	Absorption & Compr. Fac.		$1,400,000	Under Constr.	March, 1955		Gas Plt. Constr.	Gas Plt. Constr.
Warren Petroleum Corp.	Antioch, Okla.	Distl. Plt.		$2,800,000	Under Constr.	June, 1955		Gas Plt. Constr.	Gas Plt. Constr.
Warren Petroleum Corp.	Maysville, Okla.	Extraction Enlargement	19,000 bbls.	$2,800,000	Under Constr.	June, 1955		Gas Plt. Constr.	Gas Plt. Constr.
SOUTHWEST									
Allied Chem. & Dye Corp.	Orange, Texas	Ethanolamines				1955			
American Cyanamid Company	New Orleans, La.	Anhydrous Ammonia Plt.	300 tons	$50,000,000	Complete			Chemico	Chemico
*American Republics Corp., et al	Silsbee, Texas	Gaso. Plt.	20 Mmcf		Under Constr.	Aug., 1955			Olsen
Avtane Refining Co.	Freeport, Texas	Refinery: Crude Topping Vacuum Dist. Cat. Reform. Cat. Crker. Also Dehydrogenation & Alkylation Units	10,000 bbls. 10,000 bbls. 5,000 bbls. 2,000 bbls. 4,000 bbls.		Planning	Mid-July, 1955		Tears	
*Carbide and Carbon Chemicals Co.	Seadrift, Texas	Butadiene Plt.		$2,295,000	Planning (Unconfirmed)				
Chillicothe Petrochemicals, Inc.	Chillicothe, Tex	Petrochemical Plt. Ammonia Urea	180-200 tons 150 tons	$12-14,000,000	Unconfirmed				
Cities Service Oil Co., et al	Seminole, Texas	Nat. Gas Plt.	55,000 gals.		Complete				Delta
Columbian Carbon Co.	North Bend, La.	Carbon Black Plt	60,000,000 lbs./yr.		Under Constr.	Initial Unit Complete Nov., 1954; Entire Plt. Nov., 1955			
Commercial Solvents Corp.	Sterlington, La.	Nitroparaffins Fac.		$5,000,000 (Incl. Peoria, Ill.)	Under Constr.	4th Qtr., 1955		Staff	Ford, Bacon & Davis
Commercial Solvents Corp.	Sterlington, La.	Ammonia, Methanol, Ammonium Nitrate	Double Ammonia-Methanol	$20,000,000	Complete			Staff	Ford, Bacon & Davis
Cons. Chem., Ind.	Baytown, Tex.	Alky. Sulfuric Acid-Regen. Plt. & Sulfur Burning Acid Plant	600 tons	$4,500,000	Under Constr.	July, 1955		Chemico	Chemico
Cons. Chem., Ind.	Houston, Texas	Alky. Sulfur Acid-Regen. Plt.	400 tons	$3,500,000	Under Constr.	July, 1955		Chemico	Chemico
Corpus Christi Refining Co.	Tucker, Texas	Modernization			Planned				
Crown Central Petroleum Corp.	Houston Texas	Houdriformer	5,500 bbls.	$1,500,000	Complete		Houdry	Blaw-Knox	Blaw-Knox
Danaho Refining Co.	Pettus, Texas	TCC Cat Crker. w/Reform.	3,500 bbls.	$2,600,000	Under Constr.	3rd Qtr., 1955	Soc.-Vac.	Koch	
		Cat. Poly.	265 bbls.						
		Crude Expan. Gas Conc.	7,500 bbls.						
Danaho Refining Co.	Pettus, Texas	Platformer	1,000 bbls.		Under Constr.	Dec., 1955	U.O.P.	Staff	Staff
Dow Chemical Co.	Velasco, Texas	Glycerin Unit, Polyethylene		$18-20,000,000	Under Constr. Under Constr.	Jan., 1956 Aug., 1955			
Dow Chemical Co.	Freeport, Texas	Soda Ash Plt.	300 tons	$3,000,000	Under Constr.	1955			
Dow Chemical Co.	Freeport, Texas	Ammonia Plt.		$3,600,000	Complete				
Du Pont	Beaumont, Tex.	Methionine Plt.		$4,000,000	Complete				
Eastern States Petroleum Co.	Houston, Texas	Coking Plt.	13,000 bbls.	$4,000,000	Projected				
Esso Standard	Baton Rouge, La.	Fluid Hydroforming Unit	20,000 bbls.		Under Constr.	1st Qtr., 1955		S.O.D., Braun	Braun
Ethyl Corp.	Baton Rouge,	15% Increase in Anti-Knock Compound Output			Under Constr.	Early, 1955			
Ethyl Corp.	Houston, Texas	15% Increase in Anti-Knock Compound Output			Under Constr.	Early, 1955			
D. D. Feldman Co.	Lake Arthur, La.	Petrochem. Plt.		$843,000	Applied for certificate of necessity				
Gulf Oil	Port Arthur, Texas	Platforming	20,000 bbls.		Under Constr.	2nd Qtr., 1955	U.O.P.	Fluor	Fluor
Gulf Oil	Port Arthur, Texas	Exp. Ethylene Fac.	3,000 Mmcf/yr.		Under Constr.	2nd Qtr., 1955		S&W, Badger Div.	S&W, Badger Div.
Gulf Oil Co.	Port Arthur, Texas	Gas Purification Unit			Under Constr.	Feb., 1955		Girdler	Girdler
Gulf Refining, Humble Oil & Refining, The Texas Co.	St. Landry Parish, La.	Cycling & Gasoline Plt.		$10,000,000	Complete				
Gulf Refining	St. Landry Parish, La.	Nat. Gaso. Fac.		$5,000,000		2nd Qtr., 1955			
Gulf Oil Co.	Runnels Co., Texas	Fac. for Processing Nat. Gas	393 bbls.	$400,000	Complete				

• Construction boxscore continued on page 193

300,000 PPH BOILER CLEANED CHEMICALLY IN ONE DAY!



Dowell engineers bring solvents to the job in truck-mounted tanks, along with all pumping and control equipment. They apply the chemicals as necessary—by filling, spraying, jetting, cascading or vaporizing.

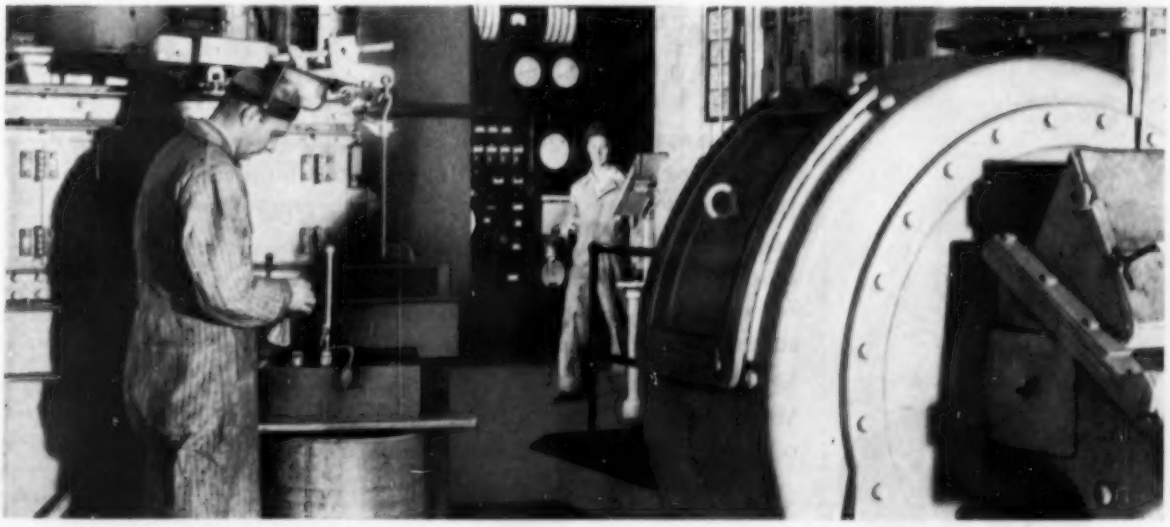
Comparative cases showed DOWELL cleaning took less time . . . removed more scale than mechanical methods

This is a case history on a 300,000 pound per hour boiler in a refinery. A routine inspection showed that iron oxide and silicate scale fouled the tubes. Dowell engineers cleaned the boiler with chemical solvents in less than 22 hours.

Dowell chemical cleaning is the standard method of removing deposits from boilers in this plant. Comparative tests showed that the chemical method was both faster and more thorough than the mechanical means previously used. The operator was surprised at the relatively large amounts of scale and sludge removed by chemical cleaning. Dowell has cleaned 25 of the 27 boilers in this plant. Several have been cleaned as many as three times on an annual basis.

Dowell liquid solvents go wherever steam and water flow, reaching surfaces inaccessible to other methods. No special scaffolding is required. *Dismantling and down-time are kept to a minimum.* Often, equipment may be cleaned while in operation.

Perhaps chemical cleaning could improve the efficiency of equipment in your plant—for example, heat exchangers, piping systems, tanks and process towers. For complete information and estimates, call the nearest of more than 130 Dowell offices, or write directly to Dept. A-31, DOWELL INCORPORATED, TULSA 1, OKLAHOMA.



DOWELL SERVICE

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

THE REFINERY THAT WAS BOUGHT "SIGHT UNSEEN"

THE owners bought this plant before the plans were on paper. You'll be doing that, too, when you sign a contract for your new plant—and you'll have to be *sure* of the qualifications of the firm you hire.

McKee has a long, successful record of sound, practical engineering and construction of projects like yours all over the world. It's the result of accurate analysis and thorough thinking-through of every detail of design, construction and equipment by a well-qualified staff of experienced technical specialists and field personnel.

You can't buy your plant *after* it's built, but you *can* make sure it will be correctly designed and efficiently constructed when you call in McKee.

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British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Heyden Chemical & Monsanto Chemical	Texas City, Tex.	Methanol Plt.	1,600 bbls.	$8,000,000	Projected	Jan., 1955	.....	.....	.....
Humble Oil & Refining Co.	Baytown, Texas	Hydrofcrmer	20,000 bbls.	....	Planning (Unconfirmed)	.....	.....	.....	.....
Jefferson Chemical Co.	Port Neches, Texas	Inc. Ethanolamines Prod.	50% Increase	....	Complete	.....	.....	Jefferson Chem. Co.	Jefferson Chem. Co. by Sub-Contract
Koppers Co.	Port Arthur, Tex.	Polyethylene Plt.	.....	.....	Under Constr.	Mid 1955	.....	Koppers	Koppers
Llano Grande Corp.	Lehman, Texas	Gaso. Plt.	25 Mmcf	$5,000,000	Complete	.....	.....	Tellepsen, Petro-Chem.	Tellepsen, Petro-Chem.
Lion Oil Co.	Luling, La.	Nitrogen Fertilizer Solution Plt.	300 tons	$215,000	Complete	.....	.....	Lion	Lion
Magnolia Petroleum	Beaumont, Tex.	Therm. Cat. Reforming	17,000 bbls.	$10,000,000	Complete	.....	Sor.-Vac.	.....	Lummus
*Magnolia Petroleum Co.	Vandertilt, Tex.	Gaso. Plt. Exp.	30 Mmcf	.....	Under Constr.	March, 1955	.....	.....	Delta
McBride Refining Co.	Port Brownsville, Texas	Ref. Expan.	†12,500 bbls.	$2,500,000	Planned	.....	.....	.....	.....
McMurrey Refining Co.	Tyler, Texas	Avia. Gaso. Plt.	.....	$3,000,000	Engineering	June, 1955	.....	Blaw-Knox, Kellogg	Blaw-Knox
McMurrey Refg. Co.	Port Brownsville, Texas	Ref. Expan.	†12,500 bbls.	Planned	.....	.....	.....	.....	Kellogg
Monsanto Chemical	Texas City, Tex.	Polyethylene Plt.	66,000,000 lbs./year	.....	Under Constr.	1st Qtr., 1955	.....	Monsanto	Farnsworth & Chambers
Pan American Refining Corp.	Texas City, Tex.	Methyl Mercaptan Plt.	5 million lbs./yr.	.....	Complete	.....	.....	.....	Rust
Pan American Ref.	Texas City, Tex.	Ultraforming	21,200 bbls.	.....	Under Constr.	Feb., 1955	.....	.....	Kellogg
Payne & Johnston, & B. G. Byars	Nolan County, Texas	Nat. Gaso. Plt.	6-8 Mmcf	.....	Complete	.....	.....	.....	Gaso. Plt.
Petrolite Corp.	Sweeny, Texas	Pet. Ref.	.....	$25,899	DPA Certified	.....	.....	.....	.....
Petrolite	Destrehan, La.	Pet. Ref.	.....	$60,000	DPA Certified	.....	.....	.....	.....
Phillips Petroleum Co.	Borger, Texas	Platformer	.....	$2,200,000	Complete	.....	U.O.P.	Phillips	Phillips
Phillips Pet. Co.	Sweeny, Texas	UOP Platformer	16,000 bbls.	.....	Complete	.....	U.O.P.	Procon	Procon
Premier Pet. Co.	Longview, Tex.	Cat. Poly. Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
Shell Chemical Corp.	Houston Texas	Glycerine Plt. Extension	.....	.....	Under Constr.	1st Qtr., 1955	.....	Pioneer	Pioneer
Shell Chem. Corp.	Houston, Texas	Epon Plt. Exp.	.....	.....	Under Constr.	2nd Qtr., 1955	.....	Lummus	Lummus
Shell Chemical Corp.	Norco, La.	Chlorohydrins for Glycerine & Epon Resins	.....	.....	Under Constr.	1st Qtr., 1955	.....	Fluor	Fluor
Shell Oil	Iowa, La.	Inc. Cap. Gaso. PH	†55 Mmcf	$600,000	Under Constr.	1st Qtr., 1955	.....	Olsen	Olsen
Sinclair Refining Co.	Houston, Texas	Sulfur Recov. Plt.	30 tons	$1,000,000	Complete	.....	.....	Parsons	Parsons
Sinclair Refining	Houston, Texas	Cat. Reformer	24,000 bbls.	.....	Planning (Unconfirmed)	.....	.....	.....	.....
Spencer Chemical	Orange, Texas	Polyethylene Plt.	45,000,000 lbs./year	$15,000,000	Under Constr.	Spring, 1955	I.C.I. of England	Staff, Hedrick Engineering	Quaker Valley Constr.
Standard Oil Co. of Texas	El Paso, Texas	Platformer	4,300 bbls.	.....	Planning (Unconfirmed)	Mid- 1955	U.O.P.	.....	.....
Stanolind Oil & Gas	Brownsville, Texas	Recondition & Revamp	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Sunray Oil Co.	Sarepta, La.	Cycling & Gasol Plt.	12 Mmcf.	$1,300,000	Complete	.....	.....	Born Eng.	Born Eng.
*Sunray Oil Corp.	Branch, La.	Cycling & Gaso. Plt.	24 Mmcf	$1,500,000	Under Constr.	Dec., 1955	.....	.....	.....
Suntide Refining Co.	Corpus Christi, Texas	Alkyl. Expan.	To 70,000 bbls.	.....	Projected	.....	.....	.....	.....
The Texas Co.	Port Arthur, Texas	No. 2 Catalytic Reformer	20,000 bbls.	.....	Under Constr.	2nd Qtr., 1955	.....	Staff, U.O.P. and Others	Lummus and Others
The Texas Co.	Amarillo, Texas	Expan & Mod. Cat. Cracker, Cat. Reform., Atmos. Crude Pipe Still, Delayed Coker, Alky. Unit, Cat. Poly., Treating & LPG Handling Fac.	†7,500 bbls.	.....	Complete	.....	.....	Kellogg, U.O.P. & Others	Kellogg & Others
The Texas Co.	El Paso, Texas	Expan. & Mod. Atmos. Crude Pipe Still, Cat. Reform., Cat. Cracker, Delayed Coker, Cat. Poly., Treating & LPG Handling Fac.	†5,400 bbls.	.....	Complete	.....	.....	Foster Wheeler U.O.P., Others	Foster Wheeler & Others
*Texas Butadiene & Chemical Corp.	Settegast, Texas	Aviation Alkylate, Butylenes & Butadiene	5,000 bbls.	$29,599,000	Planned	.....	.....	.....	Fluor
Texas Eastman Co.	Longview, Tex.	Syn. Hard Wax Plt.	15,000,000 lbs./yr.	$3,800,000	Complete	.....	.....	.....	.....
Texas Eastman Co.	Longview, Tex.	Polyethylene Plt.	20,000,000 lbs./yr.	$7,000,000	Complete	.....	.....	.....	.....
*Texas Natural Gasoline Corp.	Coke County, Texas	Gathering System & Nat. Gaso. Plt.	70 Mmcf	.....	Under Constr.	Oct., 1955	.....	.....	.....
Texas Natural Gasoline Corp. & H. W. Bass & Sons	Grayson & Coke Counties, Tex.	Additions to Gas Gathering System & Nat. Gas Proc. Plt.	.....	$1,336,900	Under Constr.	March, 1955	.....	.....	.....
Texas Gulf Producing Co.	Ector County, Texas	Gas Plt.	15 Mmcf	$1,750,000	Complete	.....	.....	Braun	Olsen
ROCKY MOUNTAIN									
Arizona Refineries	Coolidge, Ariz.	Refinery	25,000 bbls.	Part of $100,000,000 Project	Planning	Jan., 1956	.....	Ebasco Services	.....
Atlantic Refining Co.	Lovington, N.M.	Natural Gas	25 Mmcf.	.....	Projected	.....	.....	.....	.....
*Jack Bishop Group	Phoenix, Ariz.	Refinery	5,000 bbls.	$6,000,000	Proposed (Unconfirmed)	.....	.....	.....	.....
Carter Oil Co.	Billings, Mont.	Fluid Cat Crker Expansion	25,000 bbls.	.....	Complete	.....	.....	Staff	Braun
Continental Oil, et al	Brush, Colo.	Nat. Gaso. Plt. & Gathering System	10 Mmcf	.....	Under Constr.	Jan., 1955	.....	.....	Fish

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Continental Sulphur & Phosphate Corp.	Thermopolis, Wyoming	Sulfur Extraction	50 tons/yr.	.....	Under Constr.	.....	American Sulfur & Refining	.....	Chemico
Cullen Group	Newcastle, Wyo	Gas Plt.	.....	$4,500,000	Planned	.....	.....	.....	.....
Famariss Oil & Refining Co.	Monument, N. M.	Cat. Reforming Unit	650 bbls.	$375,000	Scheduled	Spring, 1955	U.O.P.	U.O.P.	Famariss Oil & Refining Co.
First National Petroleum Corp.	Jensen, Utah	Ref. Expan.	To 3,000 bbls.	.....	Planned	.....	.....	.....	.....
Four States-Western Oil Refining Co.	Farmington, N. M.	Refinery	2,000 bbls.	$200,000	Complete	.....	.....	.....	.....
Jefferson Lake Sulphur Co.	Manderson, Wyo.	Sulfur Recov. Plt.	111 tons	$600,000	Complete	.....	.....	Parsons	Parsons
Navajo Refineries	Albuquerque, N. M.	Refinery	10,000 bbls.	Part of $100,000,000 Project	Planning	Jan., 1956	.....	Ebasco Services	.....
Ohio Oil Co.	West Sidney Field, Nebr.	Nat. Gaso. Plt.	12 Mmcf	.....	Complete	.....	.....	.....	Stearns-Roger
*Pure Oil Co., et al	Adena Field, Colo.	Nat. Gaso. Plt.	20 Mmcf	$3,000,000	Planned	.....	.....	.....	Stearns-Roger
Salt Lake Chemical Co.	Salt Lake City, Utah	Synthetic Ammonia Plt.	120 tons of Ammonia 30 tons dry ice.	$7,800,000	Under Constr.	3rd Qtr., 1955	.....	Texas	Texas, Henry C. Beck Co.
Salt Lake Refining Co.	Salt Lake City, Utah	Fluid Cat. Crker	8,000 bbls.	$2,500,000	Under Constr.	April, 1955	.....	Fluor	Fluor
Socony-Vacuum Oil Co., et al	Manderson, Wyo.	Gas Processing Plt.	.....	$1,500,000	Complete	.....	.....	Parsons	Parsons
Standard Oil (Ind.)	Casper, Wyo.	Ultraformer	3,375 bbls.	.....	Complete	.....	.....	.....	Lummus
*Standard-Indiana	Casper, Wyo.	Heavy Oils, Mod. & Expan.	.....	.....	Planning	1957	.....	.....	.....
Union Oil Co. (Calif.)	Cut Bank, Mont.	Unifining Unit	100 bbls.	$100,000	Complete	.....	Union Oil	Parsons	Parsons
*U. S. Steel Corp.	Geneva, Utah	Anhydrous Ammonia	200 tons	$20,000,000	Planned	1956	.....	Blaw-Knox	Blaw-Knox
Utah Chemical Co.	Sanpete Valley, Utah	Ammonia Plt.	278 tons	$18,800,000	Planned	End, 1955	.....	.....	Cat. Constr.
*Warren Petroleum Corp.	Monument, N.M.	Extraction Enlargement	5,100 bbls.	$620,000	Under Constr.	April, 1955	.....	Staff	Trend Constr. Co.
*Warren Petroleum Corp.	Lovington, N. M.	Add. Distl. & Compr. Fac.	3,300 bbls.	$1,700,000	Under Constr.	April, 1955	.....	Staff	Dresser Engr. Co.
Western States Refg.	Salt Lake City	Topping; Crker	3,000/2,200 bbls.	$1,100,000	.....	.....	.....	.....	.....
WEST COAST									
Brea Chemicals, Inc.	Brea, Calif.	Nitric Acid & Ammonium Nitrate Plt.	.....	$2,500,000	Compete	.....	.....	Braun	.....
Calstate Refg. Co.	Signal Hill, Calif.	Hyperformer Unit	1,100 bbls.	$300,000	Under Constr.	.....	Union Oil	.....	Calstate
Caminol	Hanford, Calif.	Petroleum Refining Fac.	.....	$1,600,000	ODM Approved	.....	.....	.....	.....
Carbide & Carbon Chemicals Company	Torrance, Calif.	Polyethylene Plt.	60 million lbs./yr.	$36,000,000	Under Constr.	End, 1955	.....	.....	.....
Columbia River Chemicals	Pasco, Wash.	Anhydrous Ammonia Urea Ammonium Sulfate	160 tons 110 tons 140 tons	$12,000,000	To Begin Late 1954	Late 1955	.....	Fluor	Fluor
General Pet. Corp.	Ferndale, Wash.	Refinery	35,000 bbls.	$35,000,000	Complete	.....	.....	Bechtel	Bechtel
Hancock Oil Co.	Signal Hill, Calif.	Cat. Crker. & Facilities	6,000 bbls.	$3,500,000	Under Constr.	Feb., 1955	Soc-Vac.	Parsons	Parsons
Hancock Oil Co.	Signal Hill, Calif.	Cat. Poly.	500 bbls.	.....	Under Constr.	Feb., 1955	U.O.P.	Parsons	Parsons
Hancock Oil Co.	Signal, Hill Calif.	Fluid Coking Unit	6,000 bbls.	$1,814,800	ODM Certified	.....	.....	.....	.....
Hancock Oil Co.	Long Beach,	Cat. Reformer	2,500 bbls.	$550,000	ODM Certified	.....	.....	.....	.....
*Pacific Oil & Refining Co.	Tacoma, Wash.	Refinery	10,000 bbls.	.....	Constr. to start March (Unconfirmed)	.....	.....	.....	.....
Rothschild Oil	Santa Fe Springs, Calif.	Cat. Crker.	6,000 bbls.	$2,000,000	.....	.....	.....	.....	Braun
Shell Chem. Corp.	Martinez, Calif.	Ionol Plt. Exp.	.....	.....	Under Constr.	3rd Qtr., 1955	.....	Staff	Staff
Shell Oil	Anacortes, Wash.	Refinery	50,000 bbls.	$75,000,000	Under Constr.	End, 1955	.....	Bechtel	Bechtel
Signal Oil & Gas	Los Angeles, Calif.	Butanes-Isobutane	.....	$500,000	.....	.....	.....	.....	.....
Standard (Calif.)	Richmond, Calif El Segundo, Calif.	Cat. Reformer Cat. Reformer	.....	$30,000,000	Under Constr.	April, 1955	.....	Bechtel Bechtel	Bechtel Bechtel
Standard (Calif.)	Richmond, Calif.	Isophthalic Plt.	50 mln. lbs./yr.	.....	Engineering	Oct., 1955	.....	Staff	Ferguson
*Standard Oil (Calif.)	El Segundo, Calif.	Offsite Fac.	.....	.....	Under Constr.	.....	.....	Fluor	.....
*Standard Oil (Calif.)	Honolulu Territory of Hawaii	Refinery	20-30,000 bbls.	$25-30,000,000	Planned	.....	.....	.....	.....
Stauffer Chemical	Compton, Calif.	Sulfuric Acid	.....	$57,070	Engineering	.....	.....	.....	.....
Stauffer Chemical	Richmond, Calif	Sulfuric Acid	.....	$283,500	.....	.....	.....	.....	.....
Sunset Oil Co.	Portland, Ore.	Refinery	20,000 bbls.	.....	Considering	.....	.....	.....	.....
The Texas Co.	Wilmington, Calif.	Platforming	10,000 bbls.	.....	Under Constr.	2nd Qtr., 1955	.....	Braun & Others	Braun & Others
The Texas Co.	Wilmington, Calif.	Hydrotreating	10,000 bbls.	.....	Under Constr.	2nd Qtr., 1955	.....	Braun & Others	Braun & Others
The Texas Co.	Wilmington, Calif.	Isomerization	1,000 bbls.	.....	Under Constr.	2nd Qtr., 1955	.....	Staff	Staff
Tide Water Associated Oil	Avon, Calif.	Hydrobon-Platformer	10,000 bbls.	.....	Complete	.....	U.O.P.	Braun	Braun
Union Oil (Calif.)	Oleum, Calif.	Unifining Unit & Auxiliary Fac.	15,750 bbls.	.....	Complete	.....	Union Oil	Braun	Braun
Union Oil (Calif.)	Oleum, Calif.	Site Work and General Fac. for Unifiner & Platformer	.....	$13,550,000	Complete	.....	.....	Bechtel	Bechtel
Union Oil (Calif.)	Oleum, Calif.	Platformer and Auxiliary Fac.	14,500 bbls.	.....	Complete	.....	U.O.P.	Braun	Braun
Union Oil (Calif.)	Oleum, Calif.	Increase Grease Mfg. Cap.	.....	$600,000	Complete	.....	.....	Bechtel	Betchel
Union Oil (Calif.)	Oleum, Calif.	Unisol Unit	5,000 bbls.	.....	Under Constr.	Feb., 1955	.....	Fluor	Fluor
Union Oil (Calif.)	Oleum, Calif.	H_2S Recovery	.....	.....	Complete	.....	.....	Fluor	Fluor
Union Oil (Calif.)	Oleum, Calif.	Sulfur Plt.	60 tons	.....	Under Constr.	Mar., 1955	.....	Fluor	Fluor
Union Oil (Calif.)	Los Angeles, Calif.	Ammonia Sulfate Plt. Cap. Increase	.....	$150,000	Complete	.....	.....	E & A	E & A
Union Oil (Calif.)	Los Angeles	Fac. for Handling Enriched Crude	.....	$950,000	Engineering	.....	.....	Fluor	Fluor

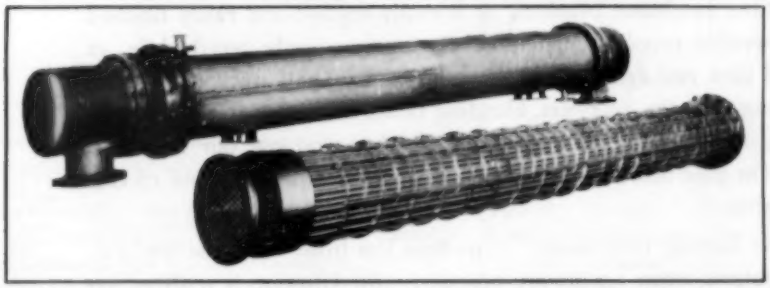
* Construction boxscore continued on page 197

BRIDGEPORT BRASS COMPANY
CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

Bridgeport MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND. — IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Duplex Tubes and Double Tube Sheet Construction Solve Corrosion Problems



Bridgeport Duplex Tubes were used with this double tube sheet heat exchanger. The inside of the tubes, the outboard tube sheet and the channels are of steel while the inboard tube sheet, the shell, and the baffles are silicon bronze. Outer tube walls are copper. (Courtesy, The Whitlock Mfg. Co., Hartford, Conn.)

In a number of specialized applications, the chance of fluid interleakage between shell and tube circuits of heat exchangers must be completely eliminated by design. Examples are: preventing contamination of product or cooling water, or preventing intermixing which might result in undesirable reactions. In such cases, independent tube sheets can be used for each circuit, giving a double tube sheet construction.

In this type of exchanger, two primary corrosion causes must generally be overcome: double fluid corrosion and galvanic corrosion. Both are met effectively and economically by Bridgeport Duplex Tubes.

Double Fluid Corrosion

Most heat exchange operations involve two fluids, each of which may have its own characteristic capacity to corrode certain metals. Water, for example, is destructive to most metals with the exception of copper and its alloys. Formaldehyde will be slightly colored by all common metals except aluminum, while sodium cyanide and ammonia corrode all common metals except steel. Thus steel tubes, which will handle ammonia on one surface, will in time be rusted through by cooling water in contact with the other surfaces.

Bridgeport Duplex Tubes combat double corrosion by offering a combination of two metals: steel, stainless steel, chrome steel, aluminum, lead, nickel, tin, etc., to the product side; and copper, aluminum brass, red brass, cupro nickel, Admiralty, aluminum bronze etc., to the cooling water side.

By drawing the proper combination of these metals to meet each set of corrosive conditions—the primary reason for the use of Duplex tubing—Bridgeport Duplex Tubes offer these advantages:

1. Effective answer to dual corrosion.
2. Considerably reduced maintenance expense.
3. Savings from reduced retubing costs.
4. Less down time.
5. Improved heat transfer.
6. Reduction of product contamination.
7. Cost economies (by replacing expensive stainless steel with Duplex Tubes of low carbon steel and copper alloy).
8. Longer life of equipment.
9. Safer, stronger construction.

All of these advantages of Duplex Tubes should be considered when designing original equipment or retubing.

A good example of Bridgeport Duplex Tube application is seen in the photo above where steel (inside) was combined with copper (outside) for the double tube sheet heat exchanger.

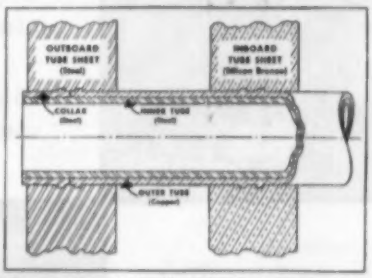
The heat exchanger also has a silicon bronze shell with baffles and inboard tube sheets to match the copper clad tubes, and steel outboard tube sheets and channel to match the tubes' steel lining.

Galvanic Corrosion

When two dissimilar metals are placed in the same solution, a small electrical current is established between them, just as in a wet-cell battery. The less noble of the two metals, say steel, corrodes at a greater rate than the more noble metal, say copper, depending on the difference in electrical potential between the two.

A steel tube sheet may thus suffer severe galvanic corrosion when coupled with copper alloy tubes and exposed to sea water, which greatly promotes corrosion of the anode metal by galvanic stimulus.

Duplex tubes can be adapted to meet this condition as shown in the drawing. Where the tube sheet is steel and a copper tube has been drawn over steel, a portion of the copper tube is cut back and a steel collar fitted over the inner



Cross section of double tube sheet construction using Duplex Tubes. To prevent galvanic corrosion, ferrules to match outer tube sheet and inner tube metal are slipped over cut-back outer tube section and expanded.

tube. This practice can be altered to fit any combination of dissimilar metals to avoid galvanic attack.

Wide Application of Bridgeport Duplex Tubes

Bridgeport Duplex Tubes, supplied in various combinations of ferrous and nonferrous materials, have been in successful use for many years. Their applications include oil refining, synthetic rubber production, process operations, chemical manufacture and refrigeration. They successfully handle such products as ammonia, amines, compressed air, flue gas, formic acid, formaldehyde, hydrogen sulfide, mercury, sulfuric acid, corrosive cooling water, and many others.

As the result of many years of intensive research, Bridgeport's Corrosion Laboratory has compiled a wide background of knowledge and experience. You may have the benefit of this experience by calling on Bridgeport's Technical Service through your local Bridgeport Sales Office. We will be glad to work with you in selecting the right combination of metals for your operating conditions. Ask, too, for a copy of Bridgeport's informative technical bulletin on Duplex Tubes. (3019)

For more data on advertised products, use Readers' Service Cards, last page.

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Then imagine how much time and money this method would save you—and at once you'll see the advantages of using ULTRALITE long glass fiber insulation blankets. It is easily applied and easily finished with weather-proofing materials. Savings are truly worthwhile, as proved time and again on oil storage tanks, asphalt truck tanks, fractionating columns, reboilers, blending tanks, etc. (And for hot or cold piping, savings are just as substantial when you use our new G-B Snap*On pipe insulation—a one-piece molded pipe insulation of fine glass fibers.)

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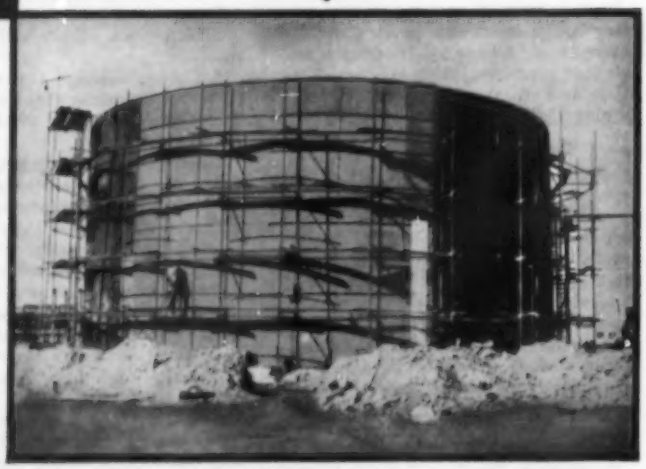

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REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Union Oil (Calif.)	Santa Maria, Calif.	Coking Plt.	18,700 bbls.	$16,475,000	Under Constr.	March, 1955		Betchel	Bechtel
Union Oil (Calif.)	Santa Maria, Calif.	Sulfur Plt.	42 tons		Under Constr.	March, 1955		Girdler	Betchel
OUTSIDE U.S.A.									
Canada									
British-American Oil Co.	Calgary	Cat. Reformer	2,000 bbls.		Under Constr.	March, 1955	Atlantic	Fluor	Fluor
British-American Oil Co.	Montreal	Cat. Reformer	13,000 bbls.		Planned	Early, 1956	Atlantic		
British-American Oil Co.	Moose Jaw	Capacity Inc.	16,000 bbls.		Engineering	Late 1955			
British-American Oil Co.	Moose Jaw	Thermal Crk. Unit			Engineering	Late 1955			
British Dominion Oil Co.	Southern Alberta, Canada	Ammonium Nitrate		$1,800,000	Planning (Unconfirmed)				
Canadian Industries (1954) Ltd.	Edmonton, Alberta	Expan. of Polyethylene Plt.	16 million lbs./yr.		Complete				
Canadian Industries, (1954) Ltd.	Millhaven, Ont.	"Terylene" Plt.	11,000,000 lbs./yr.	$20,000,000	Pilot Plt. in Operation	Mid 1955		Fergusen	Fergusen
Canadian Petrofina, Ltd.	Montreal, Quebec, Canada	Refinery, Houdriflow Cat. Cracker, Cat. Poly Dist. Unit, Vacuum Dist., Ultraformer, Fluid Coker, Alkylation, Auxiliary, Fac., Hydrodesulfurization	20,000 bbls.	$20,000,000	Under Constr.	Late 1955	Houdry, Standard of Ind., Kellogg, Standard of N.J.		Canadian Kellogg & Lummus
Canada Southern Oils	Saskatchewan	Refinery	10-20,000 bbls.	$7,000,000-$10,000,000					
Consolidated Mining & Smelting of Canada	Calgary, Alta.	Urea Plt.			Considering				
Dow Chemical of Canada	Sarnia Ontario, Canada	Ammonia Plt. Expan.		$3,000,000	Complete			Fluor Associate	Fluor of Canada
*Excelsior Refineries, Ltd.	Dawson Creek, B.C.	Thermal Cracking Unit	2,000 bbls.	$1,500,000	Under Constr.	July, 1955			Can. Kellogg
Hooker Chemicals, Ltd.	N. Vancouver, B. C.	Chemicals			Projected				
*Husky Oil & Refining, Ltd.	Moose Jaw, Sask.	Expansion Catformer	†10,000 bbls. 1,000 bbls.		Planned		Atlantic		
*Husky Oil & Refining, Ltd.	Fort William, Ont.	Inc. Cap. Catformer	†500 bbls. 1,000 bbls.		Planned		Atlantic		
Imperial Oil	Sarnia, Ontario	Asphalt Plt. Quality Control Lab. Packaging & Shipping Plt. and Mech. Shops		$6,000,000	Planned Under Constr.	1955			Canadian Bechtel
Imperial Oil, Ltd.	Edmonton, Alberta	Lube Oil Plt.	2,000 bbls.	$14,000,000	Under Constr.	July, 1955		Staff & Can. Kellogg	Can. Kellogg
Imperial Oil, Ltd.	Montreal, Quebec	25% Cap. Increase	†12,000 bbls.	$10,000,000	Complete			Staff, Can. Bechtel	Canadian Bechtel
Imperial Oil, Ltd.	Imperoyal, Canada (near Halifax)	Rebuild Existing Plt. including Fluid Cat.	41,625 bbls.	$25-30,000,000	Under Constr.	Summer, 1956		Staff & Can. Kellogg	Can. Kellogg
*Imperial Oil, Ltd.	Ioco, B.C.	Naphtha Fractionator & Cat. Poly. Plt.	2,000 bbls.	$2,900,000	Under Constr.	Oct., 1955		Staff & Can. Bechtel	Can. Bechtel
*Inland Chemicals Canada, Ltd.	Fort Saskatchewan, Alta.	Sulfuric Acid Plt.	100 tons	$1,000,000					Lummus of Canada, Ltd.
Kendall Refg. of Canada	Toronto, Canada	Cracker Lub. Oil Compounding, packaging & Distrib Plt.	27,000 bbls.		Considering	Summer, 1956 Indefinite			
McColl Frontenac Oil Co.	Edmonton, Alberta	Capacity Increase	11,000 bbls.	$4,000,000	Under Constr.	July, 1955		Staff	
McColl-Frontenac Oil Co.	Edmonton, Alberta	Thermal Cracking Unit	3,000 bbls.		Engineering	July, 1955		Can. Kellogg	Can. Kellogg
McColl-Frontenac	Montreal, East	Platformer	12,000 bbls.		Engineering	May, 1955	U.O.P.	Procon Can.	Procon Can.
Midland Pet. & Pacific Pet.	Stettler, Alta.	Crude Refinery	4,000 bbls.	$2,000,000	Under Constr.				
North Star Oil, Ltd.	St. Boniface, Manitoba	Modernization, Cat. Crker.	6,000 bbls.	$5-6,000,000	Engineering	1955	U.O.P.	U.O.P., Kellogg	Can. Kellogg
North Star Oil, Ltd.	St. Boniface, Manitoba	Refinery	12,000 bbls.	$10,000,000	Under Constr.	July, 1955	U.O.P.	Can. Kellogg	Can. Kellogg
Royalite Oil Co.	Kamloops, B.C.	FluidCat.Crker., Poly & Gas Concentration	1,425 bbls.	$2,500,000	Under Constr.	Mar., 1955	U.O.P.	Caribou Eng. Co.	Caribou Eng. Co.
Shell Oil Co.	Okotoks, Alberta	Sulfur Ext. Plt.			Planned				
Shell Oil Co. of Canada, Ltd.	Jumping Pound, Alberta, Canada	Gas Plt. Expan.	†30 Mmcf.	$1,500,000	Complete				Treco
Shell Oil of Canada	Jumping Pound Alberta, Can.	Sulfur Plt. Cap. Increase	†55 tons	$500,000	Complete			Parsons	Parsons
Sherritt-Gordon Mines, Ltd.	Fort Saskatchewan, Alta.	Anhydrous Ammonia	75 tons		Planned				
Standard Oil Company of British Columbia, Ltd.	Burnaby, B.C.	Refinery Cat. Cracker	11,000 bbls. 2,750 bbls.	$10,000,000	Complete				Fluor
Texaco Oil Co.	Edmonton, Canada	Gas Absorp. Plt.		$6,000,000	Under Constr.				
Wainwright Producers & Refiners, Ltd.	Edmonton, Alberta, Canada	Cap. Inc.	†2,300 bbls.		Planned			Treco	Treco
LATIN AMERICA									
Argentina									
Yacimentos Petroliferos Fiscales	Eva Peron	Refinery	28,300 bbls.		Complete		Kellogg	Kellogg, Y.P.F.	Y.P.F.
Yacimentos Petroliferos Fiscales (ENDE)	Luian de Cuyo Mendoza	Dist. Expan.	8,300 bbls.		Complete			Y.P.F.	Y.P.F.
Yacimentos Petroliferos Fiscales (ENDE)	Cerro Bandera P. Huincul Neuquen	Dehydration Plt.	10,400 bbls.		Under Constr.	1955		Y.P.F.	Y.P.F.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Brazil									
Companhia de Petroleo de Amazonia	Manaus	Refinery; Cat. Crker. & Aux. Units	5,000 bbls.	$4,000,000	Engineering	Late 1955	U.O.P.	Sweco	Sweco
Conselho Nacional do Petroleo	Cubatao, Sao Paulo	Therm. Crk. Ref. Reforming, Vis. Breaking Cat. Poly.	45,000 bbls.	$60,000,000	Complete		Hydrocarbon Calif. Res., Shell Dev., Edeleanu	PA Hydro Res.	PA Hydro Res. and McKee
Conselho Nacional do Petroleo	Cubatao	Anhydrous Ammonia	100 tons		Under Constr.	Late 1955	Texaco Dev.	Foster Wheeler	Foster Wheeler
Conselho Nacional do Petroleo	Bahia	Lube Oil Fac. Expansion	2,000 bbls. 10,000 bbls.	$12,000,000	Planned				
Conselho Nacional do Petroleo	Cubatao, Sao Paulo	Expansion	30,000 bbls.		Studies				
Refinaria de Petroleos de Manguinhos S/A	Rio de Janeiro	Thermal Crk., Vis-Breaking	10,000 bbls.	$12,000,000	Complete		Edeleanu PA	Kellogg PA	Kellogg PA
Refinaria e Exploracao de Petroleo "Uniao" S.A.	Capuava, Sao Paulo	TCC Recovery Cat. Poly.	20,000 bbls.		Complete		Hydrocarbon Calif. Res., Soc.-Vac.	Hydrocarbon	Hydrocarbon
Colombia									
Colombian Petro-Company	Barco Concession	Gas Treating Plt.	2,000 bbls.	$5,000,000	Under Constr.				
International Petroleum (Columbia), Ltd.	Cartagena	Refinery	25,000 bbls.	$35,000,000	Planned	Late 1957			
Mexico									
Petroleos Mexicanos	Arbol Grande Tamaulipas	Improvements			Engineering	1955		Staff	Staff
Petroleos Mexicanos	Ciudad Madero Tamulipas	Enlarge, Modern-Feed prep. Cat. Crker. Fluid-coker, Offsite	100,000 bbls.	$30,000,000	Planned	Early 1957			
Petroleos Mexicanos	Reynosa	Absorption Plt.	300 Mmcf	$10,000,000	Under Constr.	2nd Qtr., 1955		Hudson	Staff
Petroleos Mexicanos	Reynosa	Enlarge Topping Unit Thermal Cracking	5,000 bbls. 2,000 bbls.		Engineering	Late 1955	U.O.P.	Staff	Staff
Petroleos Mexicanos	Poza Rica, Ver	Expan. Gas Absorption (purification, Water and Gas Repressuring	120 Mmcf	$20,000,000	Under Constr.	1st Qtr., 1955		McKee	Staff
Petroleos Mexicanos	Minatitlan	Topping, Feed Prep., TCC Cat. Crker., Poly. Offsite	25,000 bbls.	$12,000,000	Under Constr.	3rd Qtr., 1955	Socony, U.O.P.	Fluor	Staff
Petroleos Mexicanos	Mexico, D. F.	Cap. Increase	50,000 bbls.	$12,000,000	Under Constr.	3rd Qtr., 1955		McKee	Staff
Petroleos Mexicanos	Pacific Coast	Refinery	30,000 bbls.		Planned				
Netherlands Antilles									
N. V. Curacaosche Petroleum Industrie Maatschappij	Curacao	Cat. Crker.		Part of $50,000,000 Project	Planned	End, 1957			
Peru									
Helice, S.A.	San Andres	Lube Oil; Asphalt Refinery	60,000 tons lube oil; 10,000 tons Asphalt/yr.	$8,000,000	Projected	Early 1956		Hydrocarbon	
Puerto Rico									
Caribbean Refining Co.	San Juan	Refinery	10,000 bbls.	$11,000,000	Under Constr.	1st Qtr., 1955	U.O.P.	Fluor	Fluor
Commonwealth Oil Refining Co.	Guayanilla Bay	Refinery; Houdriflow Cat. Crker.	25,000 bbls. 26,500 bbls.	$25,000,000	Under Constr.			Lummus	Lummus
		Houdriformer	3,730 bbls.						
Puerto Rican Oil Refining Co.	Near Ponce	Refinery	25,000 bbls.	$20,000,000	Projected		Undetermined	Brinckerhoff, Hall and Macdonald	
Venezuela									
Compania Shell de Venezuela	Cardon	Cat. Crker.	35,000 bbls.	Part of $56,000,000 Project	Planned	End, 1957			
Creole Petroleum Corp.	Amuay	Fluid Hydro-former	10,000 bbls.		Engineering	Feb., 1955	S.O.D.	S.O.D.	Foster Wheeler
Creole Pet. Corp.	Amuay Bay	Vac. Pipestill	42,000 bbls.	$7,000,000	Under Constr.	April, 1955		Foster Wheeler	Foster Wheeler
*Socony-Vacuum Oil Co. of Venezuela	Puerto Cabello	Refinery			Planned (Unconfirmed)				
EUROPE AND AFRICA									
Belgium									
Societe Industrielle Belge des Petroles	Antwerp	Cat. Crker.	10,000 bbls.	$10,000,000	Under Constr.	1st Qtr., 1955	U.O.P.	Lummus	Lummus
S.I.B.P.	Antwerp	Cat. Poly. Unit	3,000 bbls.		Under Constr.	1st Qtr., 1955	U.O.P.	Lummus	Lummus
Denmark									
A. P. Moeller	Copenhagen	Refinery		$11,500,000	Planning (Unconfirmed)				
Egypt									
Egyptian Government	Cairo	Refinery	20,000 bbls.		Planning			Lummus	Lummus
Egyptian Government	Suez	Inc. Refn Cap.	26,000 bbls.	$24,000,000	Planning				Lummus
England									
Berry Wiggins & Co., Ltd.	Weaste Ref., Manchester Ship Canal	Extension to Refinery	500 bbls.		Under Constr.			H.W.P.	H.W.P.
‡British Petroleum Co., Ltd.	Kent	Acid/Soda Treat.	2,100 bbls.		Under Constr.				
‡British Petroleum Co., Ltd.	Kent	Platformer	6,000 bbls.		Complete		U.O.P.	Procon (G.B.)	E. B. Badger
‡British Petroleum Co., Ltd.	Kent	Vacuum Unit	17,000 bbls.		Under Constr.			E. B. Badger, Ltd.	E. B. Badger, Ltd.
‡British Petroleum Co., Ltd.	Fawley, England	Hydroforming Unit	10-15,000 bbls.		Planned				
*Esso Petroleum Co.									
Imperial Chemical Industries	Wilton	Terylene Plt.	11 mln. lbs./yr.	$50,000,000	Under Constr.	Early 1955		Kellogg	Kellogg
Imperial Chemical Industries	Wilton	Butadiene Separation Plt.			Design			H.W.P.	
Monsanto Chemicals, Ltd.	Britain	Add Polystyrene			Under Constr.			Staff	Staff
Monsanto Chemicals, Ltd.	Britain	Styrene-Butadiene Copolymer Plt.	4,000 tons/yr.	$14,000,000	Planned				
Shell Refining & Marketing Co.	Stanlow	Hydrodesulfurization	5,200 bbls.		Under Constr.	Early 1955			
Shell Refining & Marketing Co.	Stanlow	Isopentane Plt.		$1,400,000	Under Constr.	Early, 1955		H.W.P.	

‡ Formerly Anglo-Iranian Oil Company.

• Construction boxscore continued on page 201

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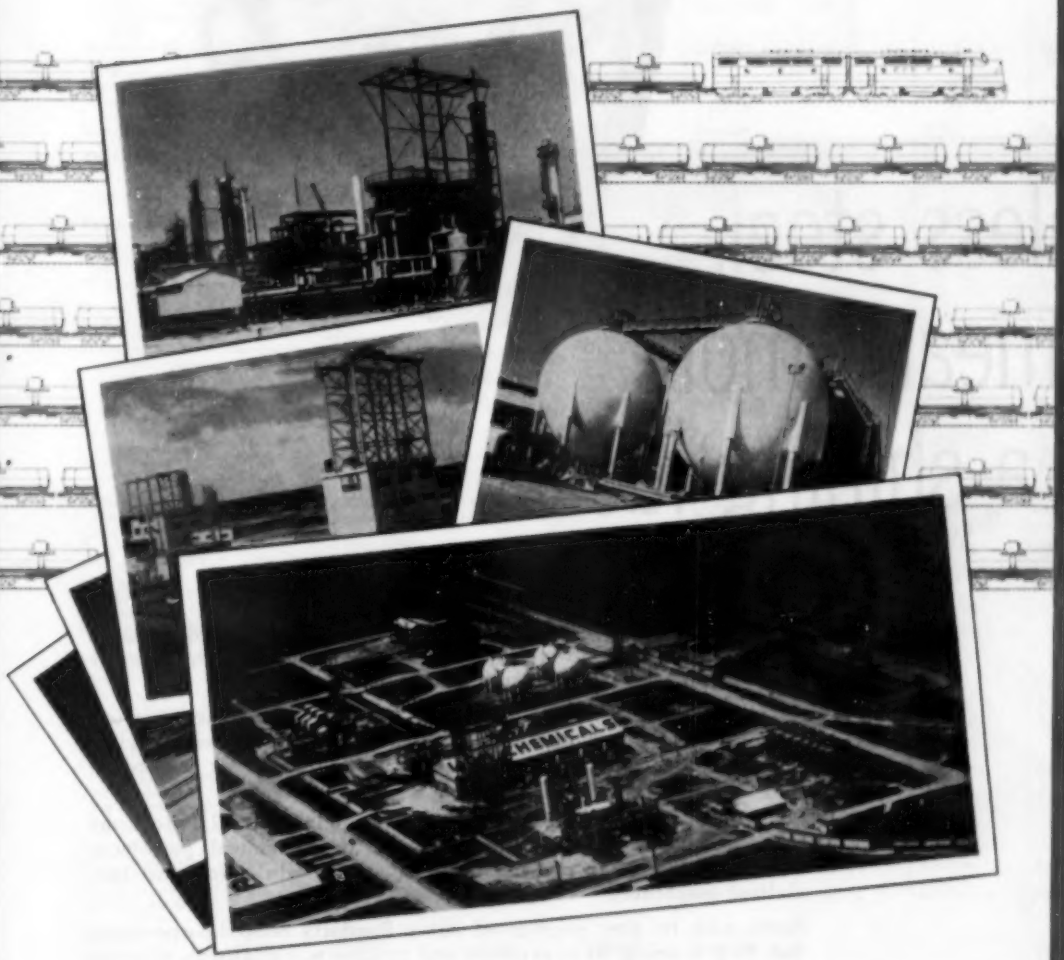

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REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell Refining & Marketing Co.	Shell Haven	Cat. Reformer	6,700 bbls.	.....	Under Constr.	End, 1955	.....	.....	.....
Shell Refining & Marketing Co.	Stanlow	Extension to Distilling Plt.	I.P.A. 67 tons S.B.A. 102 tons	.....	Design	.....	.....	H.W.P.	.....
Universal-Matthey & Co.	England	Ref. Catalyst	.....	.....	Complete	.....	.....	.....	Procon
Finland									
*Finnish Government	Finland	Refinery	9,000 bbls.	.....	Planning (Unconfirmed)	.....	.....	.....	.....
France									
*Compagnie de Raffinage Shell-Berre	Petit Gouronne	Cat. Crker.	8,000 bbls.	.....	Under Constr.	Mid 1956	.....	.....	.....
Comp. Francaise de Raffinage	Gonfreville	Refinery Expan.	.....	.....	.....	.....	.....	.....	.....
Societe des Raffineries de Petrole de la Gironde	Ambes	Cat. Crker.	4,600 bbls.	.....	Planning	1956	.....	.....	.....
		Vacuum Unit	6,700 bbls. (Product)	.....	Planning	1956	.....	.....	.....
*Societe des Raffineries de Petrole de la Gironde	Ambes	Poly Plt.	450 bbls.	.....	Under Constr.	1957	.....	.....	.....
Societe Generale Huile Petroles	Lavera	Platformer	6,000 bbls.	.....	Complete	.....	U.O.P.	Procon & E. B. Badger, Ltd.	E. B. Badger, Ltd.
West Germany									
Badische Anilin & Soda Fabrik, A.G. & Deutsche Shell	Wesseling Area	Polyethylene & Ethylbenzene pH	.....	.....	Projected	1955	.....	.....	.....
Gelsenberg-Benzin A.G.	Gelsenkirchen, Horst	Platformer	7,100 bbls.	$7,500,000	Complete	.....	U.O.P.	Procon (G.B.)	Procon (G.B.)
Kali Chemie Co.	Neinberg	Bead Catalyst Plt.	.....	.....	Licensed	.....	Soc.-Vac.	.....	.....
Greece									
Greek Government	Greece	Refinery	25,000 bbls.	$20,000,000	Planned	.....	.....	.....	.....
Italy									
I.L.S.E.A.	Valmadrera, Como	Cat. Reforming Unit	500 bbls.	.....	Under Constr.	Spring, 1955	Atlantic	Teenider	Teenider
Industria Raffinazione Olii Minerali	Venice	Cat. Crker.	10,000 bbls.	.....	Planned	.....	.....	.....	.....
*Montecatini	Barranca Bermeja	Anhydrous Ammonia Plt.	50 tons	.....	Planning (Unconfirmed)	.....	.....	.....	.....
Soc. An. Raffinazione Oli Minerali-SAROM	Ravenna	Topping Unit	15,000 bbls.	.....	Complete	.....	.....	Teenider	Staff
Societa Per Azioni Raffineria Padana Olii Minerali (SARPOM)	San Martino di Trecate (Novara), Italy	Cat. Crker.	2,880 bbls.	.....	Under Constr.	1955	U.O.P.	U.O.P., E. B. Badger, Ltd.	S&W Badger Div.
		Vacuum Unit	5,150 bbls.	.....	Under Constr.	1955	.....	S&W Badger	S&W Badger Div.
		Poly. Plt.	315 bbls.	.....	Under Constr.	1955	C.R.C.	Foster Wheeler	S&W Badger Div.
Socony-Vacuum Italiana, S.P.A.	Naples	Cat. Poly.	.....	$724,000	Under Constr.	2nd Qtr., 1955	Calif. Res.	Mediterranean Builders, Inc.	C.T.I.P.
Socony-Vacuum Italiana, S.P.A.	Naples	TCC	.....	.....	Under Constr.	2nd Qtr., 1955	Soc.-Vac.	Mediterranean Builders, Inc.	C.T.I.P.
Netherlands									
*Caltex Petroleum Maatschappij (Nederland) N.V.	Pernis	Platformer	7,000 bbls.	.....	Planning	1957	.....	.....	.....
		Desulfurization	4,000 bbls.	.....	Planning	1957	.....	.....	.....
N. V. de Bataafsche Pet. Maatschappij	Pernis	Deasphalting	12,000 bbls.	.....	Complete	.....	.....	S&W Badger Div., E. B. Badger, Ltd.	.....
N. V. Bataafsche Petroleum Maatschappij	Pernis	Luboil Ref. Exp.	1,750 bbls.	.....	Under Constr.	Early, 1955	.....	.....	.....
N. V. de Bataafsche Petroleum Maatschappij	Pernis	Cat. Crker.	33,000 bbls.	.....	Under Constr.	Mid 1956	.....	.....	.....
Scotland									
*British Petroleum Chemicals, Ltd. (Jointly Owned by AIOC & Distillers Co.)	Grangemouth	Alkylate Plt.	.....	.....	Planning (Unconfirmed)	.....	.....	.....	.....
Spain									
Empresa Nacional "Calvo Sotelo"	Puertollano	Shale Oil Refg.	3,000 bbls.	$46,000,000	Complete	.....	Basf, Lurgi	Basf, Lurgi	Basf, Lurgi
*Refineria de Petroleos de Escombreras S.A.	Escombreras	Lube Oil Plt.	27,500 net tons/yr.	.....	Under Constr.	1955	.....	Foster Wheeler	Foster Wheeler
		Crude Unit	23,000 bbls.	.....	Planned	1956	.....	.....	.....
		Platformer	8,000 bbls.	.....	Planned	1956	.....	.....	.....
Trieste									
S.P.A. Tecnico Industriale Aquila	Trieste	Cat. Cracking	3,300 bbls.	.....	Under Constr.	.....	Soc.-Vac.	Staff	Staff
S.P.A. Tecnico Industriale Aquila	Trieste	Cat. Poly.	1,400 bbls.	.....	Under Constr.	.....	U.O.P.	Staff	Staff
Turkey									
Turkish Government	Kutahya	Nitrogen Plt.	.....	.....	Projected	.....	.....	.....	.....
Turkiye Petrolleri A.O.	Batman	Refinery	6,950 bbls.	$10,000,000	Completing	.....	.....	Parsons	Parsons
Union of South Africa									
Anglo-Transvaal Consolidated Investment Co.	Vall River	Synthetic Gaso. & Diesel Oil Plt.	.....	$50-60,000,000	Contracted	.....	.....	.....	.....
South Africa Coal Oil & Gas	Coalbrook, Orange Free State	Plt. Expansion	3,500 bbls.	$50,400,000	Complete	.....	.....	.....	.....
Union Petrol Refinery, Ltd.	Johannesburg	Refinery	.....	$20,000,000	Projected	.....	.....	.....	.....
Wales									
National Oil Refineries, Ltd.	Llandarcy	Platformer	6,000 bbls.	$3,000,000	Under Constr.	Early, 1955	U.O.P.	Procon (G.B.)	E. B. Badger, Ltd.
NEAR EAST									
Bahrain									
Bahrain Petroleum Co., Ltd.	Bahrain	Vacuum Still	23,000 bbls.	.....	Planning	1955	.....	Lummus	.....
*Bahrain Petroleum Co., Ltd.	Bahrain	Cat. Crker.	18,000 bbls.	.....	Planning	1957	.....	.....	.....
		Poly Plt.	3,000 bbls.	.....	Planning	1957	.....	.....	.....
		Vacuum Still	23,000 bbls.	.....	Planning	1957	.....	Lummus	.....
Iraq									
Iraq Government	Dora	Lube Oil Plt.	25,000 tons/yr.	.....	Planned (Unconfirmed)	.....	.....	.....	.....

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Israel									
Fertilizers & Chemicals	Haifa	Hydrogen, Ammonia, Sulfuric Acid, Nitric Acid, Ammonia Sulfur, Ammonia Nitrate	.....	$15,000,000	Completing	.....	.....	Chemico	Staff
Kadimah Chemical Corp.	Haifa	Detergent Mfg.	10 tons	$500,000	Completing	.....	.....	.....	Staff
Jordan									
Jordanian Reconstruction Council	Mafrak	Refinery	.....	$7,500,000	Planned	.....	.....	.....	.....
Lebanon									
Mediterranean Refining Co.	Sidon	Refinery	9,000 bbls.	.....	Under Constr.	.....	U.O.P.	Bechtel Asso., Procon	Bechtel Asso.
Saudi Arabia									
Arabian American Oil Co.	Ras Tanura	Fluid Cat. Hydroformer	12,500 bbls.	$9,825,000	Under Constr.	Jan., 1956	S.O.D.	Lummus	Lummus
Saudi Arabian Government	Saudi Arabia	Ammonium Sulfate Plt.	600,000 Metric tons/yr. Plus 500 Tons Dry Ice	.....	Proposed	.....	.....	.....	.....
FAR EAST									
Burma									
Burma Oil Co.	Chauk	Distil. Unit	2,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
Ceylon									
Ceylon Government	Ceylon	Refinery	.....	.....	Negotiating	.....	.....	.....	.....
*Shell Co. of Ceylon, Ltd.	Hendala	Refinery	.....	.....	Planning (Unconfirmed)	.....	.....	.....	.....
India									
Burmah-Shell Refineries, Ltd.	Bombay	Refinery	40,000 bbls.	$47,000,000	Under Constr.	Early, 1955	.....	.....	.....
*Caltex Oil Refining (India) Ltd.	Visakhapatnam	Refinery	10,000 bbls.	.....	Planning	1957	.....	.....	.....
Japan									
Daikyo Oil Co., Ltd.	Yokkaichi	Houdriflow & Cat. Poly.	3,500 bbls.	.....	Under Constr.	Early, 1955	Houdry & Calif. Res.	Houdry	.....
Mitsubishi Oil Co., Ltd.	Tokyo	Vac. Distl. Unit	2,000 bbls.	.....	.....	.....	.....	.....	.....
Nippon Petroleum Refining Co., Ltd.	Yokohama	Modern. and Expansion	12,000 bbls.	.....	Under Constr.	1955	.....	McKee	McKee
Showa Oil Company	Tokuyama	Refining Fac.	.....	.....	Planning	.....	.....	.....	.....
Showa Oil Company	Tokuyama	Petrochemicals	.....	.....	Planning	.....	.....	.....	.....
Showa Oil Company	Hirasawa	Alkyl Sulfonate	2 tons (Pilot Plt.)	.....	Testing	.....	.....	.....	.....
Pakistan									
*Pakistan Petroleum, Ltd.	Baluchistan, W. Pakistan	Gas Processing Plt.	.....	$30,000,000	Planning (Unconfirmed)	May, 1955	.....	Hudson	Hudson
Sumatra									
Standard Vacuum Refinery	Sumatra	Refinery Mod.	.....	.....	.....	.....	.....	Foster Wheeler	Foster Wheeler
Taiwan									
Chinese Petroleum Corp.	Kaohsiung (Formosa)	Thermofor Cat. Crker.	10,000 bbls.	.....	Under Constr.	2nd Qtr., 1955	Soc.-Vac.	Fluor	.....
		Cat. Reformer	.....	.....	Under Constr.	2nd Qtr., 1955	Atlantic	Blaw-Knox	Blaw-Knox
*Taiwan Fertilizer, Ltd.	Nankong	Ammonia Plt. to Produce Urea	260 tons	.....	Design Stage	1956	Vulcan	NH_3-Hydrocarbon Urea—Vulcan	Hydrocarbon
AUSTRALASIA									
Australia									
Australian Oil Re-Refining, Ltd.	Kurnell	Refinery	22,000 bbls.	.....	Under Constr.	1955	.....	S.&W. Badger Div., E. B. Badger, Ltd., Ewbank & Partners, Christiani and Nielson, Foster Wheeler	E. B. Badger Pty.
†British Petroleum Co.	Kwinana	Refinery	60,000 bbls.	.....	Under Constr.	Early, 1955	.....	.....	Kellogg, Kellogg International, Costain-John Brown
Petroleum and Chemical Corp.	Silvermater	Petrochemical Plt.	.....	$7,000,000	Planned	Dec., 1955	.....	Power-Gas Corp. (Aust) Pty., Ltd.	Power-Gas Corp. (Aust) Pty., Ltd.
Shell Refining (Australia) Proprietary, Ltd.	Geelong	Cat. Crker.	12,000 bbls.	.....	Under Constr.	Mid., 1955	.....	.....	.....
Socony-Vacuum	Altona	Alkylation Unit	1,700 bbls.	.....	Planned	Aug., 1956	.....	.....	.....
Standard-Vacuum Refining Co., Ltd.	Melbourne	Refinery Expan.	25,000 bbls.	$30,000,000	Under Constr.	Jan., 1955	.....	Braun, Soc.-Vac.	Braun
Philippine Islands									
Caltex (Philippines, Inc.)	Batangas	Refinery	13,000 bbls.	.....	Complete & On Stream	.....	.....	Foster Wheeler, McKee, Bechtel	Foster Wheeler

† Formerly Anglo-Iranian Oil Company.

* First appearance in tabulation † Added capacity

NOTE:
Atlantic—Atlantic Ref. Co.
Austin—Austin Co.
Badger Mfg.—Badger Manufacturing Co.
E. B. Badger Ltd.—E. B. Badger & Sons Ltd.
E. B. Badger Pty.—E. B. Badger & Sons Pty., Ltd.
Barnes—W. W. Barnes Co.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C. F. Braun Co.
Brown & Root—Brown & Root Construction Co.
Buchner—F. J. Buchner Corp.
Calif. Res.—California Research Corp.
Can. Kellogg—Canadian Kellogg Co.
Cat. Constr.—Catalytic Construction Co.
Chemico—Chemical Construction Co.
Ch. Pro.—Chemical Process, Inc.
C. B. & I.—Chicago Bridge & Iron Co.
Chiyoda—Chiyoda Chemical Engineering & Construction Co., Ltd.
C. & I.—Chemical & Industrial Corp.
Consd. Eng.—Consolidated Engineering Company
Craig—A. P. Craig & Co.
D & Z—Day & Zimmerman
Delta—Delta Engineering Corp.
Dresser—Dresser Engineering Corp.
Esasco—Esasco Services, Inc.
E&A—Ehrhart & Arthur, Inc.
Edeleanu—Edeleanu Gesellschaft M.B.H.
Etabadger, S.A.—Etablissement Badger, S.A.
Fish—The Fish Engineering Corp.
Ferguson—H. K. Ferguson Co.
Fluor—Fluor Corp.
Foster Wheeler—Foster Wheeler Corp.
Gas Plant Constr.—Gasoline Plant Const. Corp.
Girdler—The Girdler Co.
Graf—Graf Engineering & Equipment
Gravor—Gravor Construction Co.
Grebe & Doremus—Grebe & Doremus Process Co.
Gutte-Hutte—Gutehoffnungshuette
Hercules—Hercules Powder Co.
Hudson—Hudson Engineering Corp.
H. W. P.—Head Wrightson Process, Ltd.
Hydrocarbon—Hydrocarbon Research, Inc.
Hydro M—Hydrocarbon Mineralael G.m.b.H.
Hydro E—Hydrocarbon Engineering S.A.R.L.
Kaiser—Kaiser Engineers
Kellogg—The M. W. Kellogg Co.
Kellogg P A—Kellogg Pan American
Koch—Koch Engineering Company
Koppers—Koppers Co., Inc.
Lummus—The Lummus Co.
Macco—Macco Corp.
McKee—Arthur G. McKee Co.
M-C & S—Merritt-Chapman & Scott Corp.
Olsen—O. L. Olsen
P. A. HydroRes—Pan-American Hydrocarbon Research Co.
Parker—Parker, Steffens & Pearce
Parsons—The Ralph M. Parsons Co.
Petec—Petroleum Engineering Tool Co.
Phillips—Phillips Petroleum Co.
Pritchard—J. H. Pritchard Co.
Procon—Procon, Inc.
Quaker—Quaker Valley Constructors
Rust—Rust Engr. Co.
S & B—Singmaster & Breyer Separator-Nobel Co.
Soc. Vac.—Socony-Vacuum Oil Co.
Southwestern—Southwestern Constr. Co.
S.O.D.—Standard Oil Development Co.
Sohio—Standard Oil Co. of Ohio
Stearns-Roger—Stearns-Roger Mfg. Co.
Sunland—Sunland Refining Co.
S & W Badger Div.—Stone & Webster Engineering Corp., Badger Process Div.
S & W Canada Ltd.—Stone & Webster Canada Ltd.
Sweco—Southwestern Engineering Co.
Texas—Texas Engineers
Tecnidro—Tecnica Idrocarburie Derivati
Tellepsen—Tellepsen Construction Co.
Texaco Dev.—Texaco Development Corp.
Texaco—The Texas Co.
Texas Natural—Texas Natural Gasoline Corp.
Trico—Refinery Engineering Co.
U.O.P.—Universal Oil Products Co.
Vulcan—Vulcan Copper & Supply Co.
J. G. White—J. G. White Eng. Corp

This is the Third in a series of brief summaries of the economics of electrical desalting. The first report in the series showed an average credit of 4.6¢/Bbl. for increased crude capacity. Part II described the credits for reduced maintenance, a minimum of 1.1¢/Bbl. The total of the five major credits assure a payout of better than 100%. A complete report detailing credits of electrical desalting available upon request.

TECHNICAL REPORT

SUBJECT:

ECONOMICS OF ELECTRICAL DESALTING

FROM:

RESEARCH FILES OF HOWE-BAKER CORP.

ECONOMICS OF DESALTING

THIRD IN A SERIES OF FIVE

3. CREDITS FOR IMPROVED CRACKING YIELDS

Both thermal and catalytic cracking yields are significantly improved by the removal of salt and metallic oxides. The resulting economics are discussed below. The first report in this series pointed out the significant gains in crude capacity resulting from the removal of water charged with the crude to a distillation unit. Since water requires ten times as much heat for vaporization as does oil, removal of water by electrostatic means makes possible the substitution of oil in the ratio of ten barrels of oil per barrel of water. This, plus increased capacity gained from the reduction of downtimes assures a capacity credit of about 4.6¢/bbl.

The second report showed that maintenance costs are greatly reduced by minimizing exchanger, tower, and furnace cleaning and replacement of equipment damaged by attrition. The minimum credit for reduced maintenance, based on long-time analyses of before-and-after maintenance records, totals 1.1¢/bbl.

The removal of salt and metallic contaminants has a pronounced effect on both thermal and catalytic cracking economies. In recent years, it has been well established that nickel, vanadium, and iron are all serious poisons to cat cracking catalysts. While electrical desalting by no means assures complete removal of these contaminants, it does make a significant reduction in their concentration through the removal of colloidal-dimensioned suspended solids. This removal of catalyst poisons insures sizable credits for reduced catalyst makeup and increased catalyst activity.

In the case of thermal cracking of residuum, the results are more obvious. It has been established that salt catalyzes the formation of coke and tar with a corresponding detrimental effect on the yield of gasoline. By simple material balance: a crude entering the distillation unit with a salt content of 50 ptb, and not desalted, deposits all of the salt in the outgoing residuum. Thus the concentration of the salt in the residuum will be increased to perhaps 450 ptb! It has been computed that reducing the salt content in the residuum, by electrical means, to a level of about 30 ptb, will increase gasoline yields by about 1.6%, with an equivalent reduction in coke and tar yields. The minimum credit for improving catalytic and thermal cracking operations for the average refiner will amount to 1.6¢/bbl.

In line with the principles established above, removal of salt will sharply reduce cracking in the distillation unit. This is particularly important in vacuum units, where the amount of vacuum (hence, gas oil yields) is frequently limited by cracking in the furnace. Similarly, tube failures and hot spots in furnaces will be reduced.

SUMMARY OF CREDITS

	c/Bbl
1. Increase Crude Capacity	4.6
2. Reduce Maintenance . . .	1.1
3. Improve Cracking Yields	1.6
4. Reduce Corrosion	0.6
5. Increase Tank Capacity	0.2
Total Credits	8.1

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Reviewing New Books . . .

Water from the Ocean

Fresh Water from the Ocean, by Cecil B. Ellis, The Ronald Press Company, 15 East 26th Street, New York 10, 217 pp., $5.

The recurrence of water shortages in recent years has made the need for developing sources of extra supply the special concern of industrialists, engineers, scientists, government officials and conservation-minded citizens.

In this new book, Dr. Ellis and members of the staff of the Nuclear Development Associates, Inc., take a critical look at the economic prospects of tapping the vast fresh water potential of the ocean in a large-scale operation. The book investigates the prospects for salt-water conversion in projected capacities of 1000 million gallons every 24 hours, approximately the daily consumption of New York. It provides a sound basis for weighing the practicality of present and proposed conversion methods in large-scale operation, at a cost that can be met by cities, industries and farming areas in need of water.

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Fuels Volume

Minerals Yearbook, 1952, Volume II. Fuels, Superintendent of Documents, United States Government Printing office, Washington 25, D.C. $2.25.

The initial volume of the Bureau of Mines "Minerals Yearbook" is devoted to the mineral fuels. Volume II of the Yearbook, which is being published in three volumes for the first time, contains, in addition to chapters on each mineral-fuel commodity, a review of the mineral-fuel industries in 1952, a statistical summary of production and a chapter on employment and injuries.

Volume I, containing chapters on metallic and nonmetallic minerals, and Volume III, dealing with geographic areas, will be published later.

The Minerals Yearbook series began in 1867, when the Treasury Department published "Reports Upon the Mineral Resources of the United States." For many years, first by the Geological Survey and later by the Bureau of Mines, it was published as "Mineral Resources of the United States." In 1932 the title was changed to "Minerals Yearbook."

A three-volume edition was made necessary by an increase in Yearbook material that could no longer be published under a single cover without making the book so thick as to cause binding problems, and so heavy that it would inconvenience the reader.

The change to three volumes has not only permitted fuller coverage in all phases of the reports, but has made possible major expansion in the geographical section (Volume III) and in reviews of technologic developments and problems.

Clear Presentation

Handbook of Graphic Presentation, by Calvin F. Schmid, The Ronald Press Company, 15 East 26th Street, New York 10, 320 pp., $6.

This book is a working manual for all who are concerned with the clear presentation and interpretation of statistical data by means of charts and graphs. It shows how complicated data of many kinds may be put into a form easily intelligible to the busy executive or the general public.

The book analyzes each of the basic types of statistical charts in detail, with particular reference to its advantages and disadvantages in presenting data of different kinds. There is a step-by-step description of the procedure for laying out statistical charts, a complete and authoritative discussion of statistical maps and a thorough treatment of three-dimensional charts and graphs.

Physical Property Data

Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds, Carnegie Press, Carnegie Institute of Technology, Pittsburgh 13, Pa., 1050 pp., $7.

This volume, published for the American Petroleum Institute by Carnegie Press, represents a compilation of data developed by the staff of API Research Project 44. It provides, in bound form, information which

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New Books . . .

has been made available in loose-leaf sheets on physical and thermodynamic properties and includes all material extant as of December 31, 1952.

Contents include 747 pages of tables of properties, 191 pages of specific references, 68 pages of general references, indices of properties and compounds, and a list of publications. Properties covered, for 1030 hydrocarbons and related compounds, are given.

Diesel Fuels

Symposium on Diesel Fuels, American Society for Testing Materials, 1916 Race Street, Philadelphia 3, 56 pp., $1.50.

The papers presented in this booklet were part of a symposium sponsored by the ASTM Committee D-2 on Petroleum Products and Lubricants held in Philadelphia last February.

Of the nine papers presented in the symposium, eight were prepared covering the diesel fuel supply and demand outlook, and the various problems associated with the procurement and usage of diesel fuels, while one paper is a review of fuel specification requirements.

The nine papers and their authors, which are introduced by W. King Simpson, General Motors Corporation and chairman of the Technical Committee F on Diesel Fuels of Committee D-2, are:

- "The Availability and Demand Outlook, Distribution and Principal Properties of Domestic Diesel Fuels," C. M. Larson, Sinclair Refining Company.
- "The Increasing Use of Furnace Oils for Diesel Fuel," Harold V. Messick, Ashland Oil and Refining Company.
- "Distribution and Storage Problems with Diesel Fuels," C. C. Moore and W. P. Lakin, Union Oil Company of California.
- "Survey of Diesel Fuel Oils Available at Roadside Filling Stations," W. A. Howe, Gulf Oil Corporation.
- "Technical Problems Associated with Diesel Fuels in Contractors' Equipment," J. W. Vollentine, Caterpillar Tractor Company.
- "Technical Problems Associated with Diesel Fuels Interstate Coach Operation," W. A. Duvall, The Greyhound Corporation.
- "Technical Problems Associated with Diesel Fuels in Railroad Operations," R. W. Seniff, The Baltimore & Ohio Railroad Company.
- "Diesel Fuels in Marine Operations," C. E. Habermann, Socony-Vacuum Oil Company.
- "Diesel Fuel Specifications Requirements," C. C. Ward, U. S. Bureau of Mines, U. S. Department of the Interior, Bartlesville, Okla.

Welding Engineering

Welding for Engineers, Harry Udin, Edward R. Funk and John Wulff, John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16. $7.50.

This new book is not a mere handbook of familiar techniques but a clear presentation of the basic principles and practices of welding engineering. The

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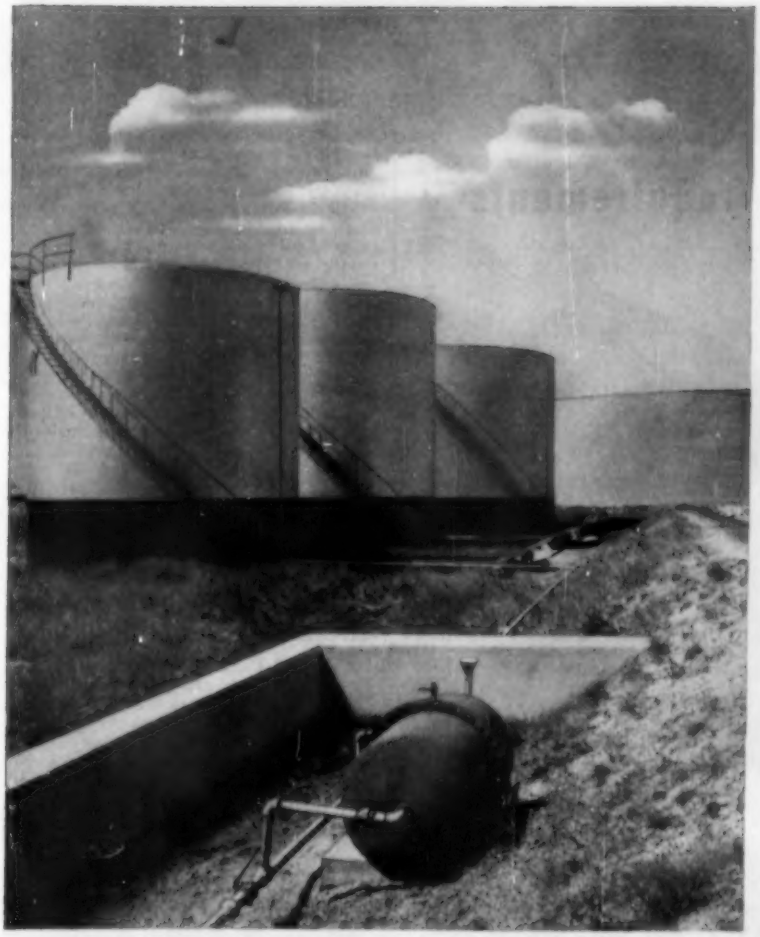

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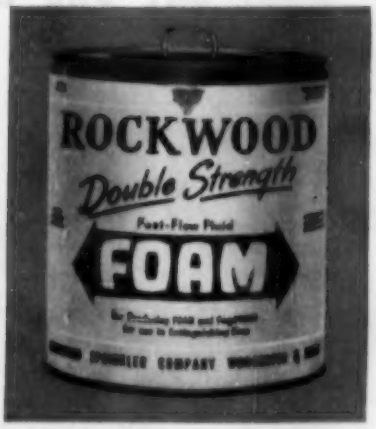

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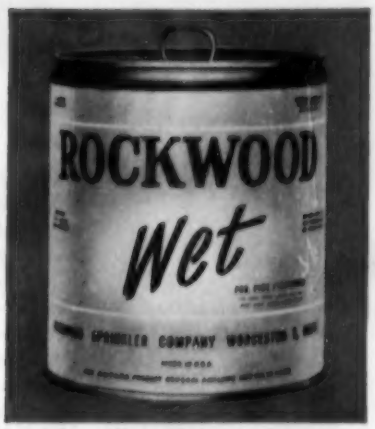

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Chemical Engineering

Chemical Engineering, Volume I, by J. M. Coulson and J. R. Richardson, McGraw-Hill Book Company, 330 W. 42nd Street, New York 36.

TLis book treats the important chemical mechanisms of diffusion, fluid flow, and heat transfer in great detail, especially from the mathematical point of view, and gives the necessary background for applying these mechanisms in a variety of unit operations.

This first volume of a two-volume work is divided into four sections: fluid flow, heat transfer, mass transfer and humidification. The last section is used as a practical illustration of a process involving both heat and mass transfer simultaneously.

The first section of the book considers the problem of fluid flow from a thermodynamic aspect and derives general equations over a wide range of circumstances.

A section on heat transfer gives an account of the generally accepted techniques for calculating film transfer coefficients for many conditions. Also included is informative material on the general construction of tubular exchangers, a major feature of many installations. The possibilities of the newer plate type units are indicated.

The section on mass transfer introduces the mechanism of diffusion. This is followed by an explanation of the common relationships between heat, mass and momentum transfer and the boundary layer theory.

The section on humidification discusses wet bulb temperature, adiabatic saturation temperature, water cooling, design of a humidifying tower and a system other than air-water.

Price Requoted

Price of *Corrosion Problems and Prevention in the Chemical and Petro-Chemical Industries,* published by the Organisation for European Economic Co-operation, was misquoted in the November issue of PETROLEUM REFINER. The price is $1.50 per copy. Copies may be obtained by writing the O.E.E.C., Publications Office, 2002 P Street, N.W., Washington 6, D.C.

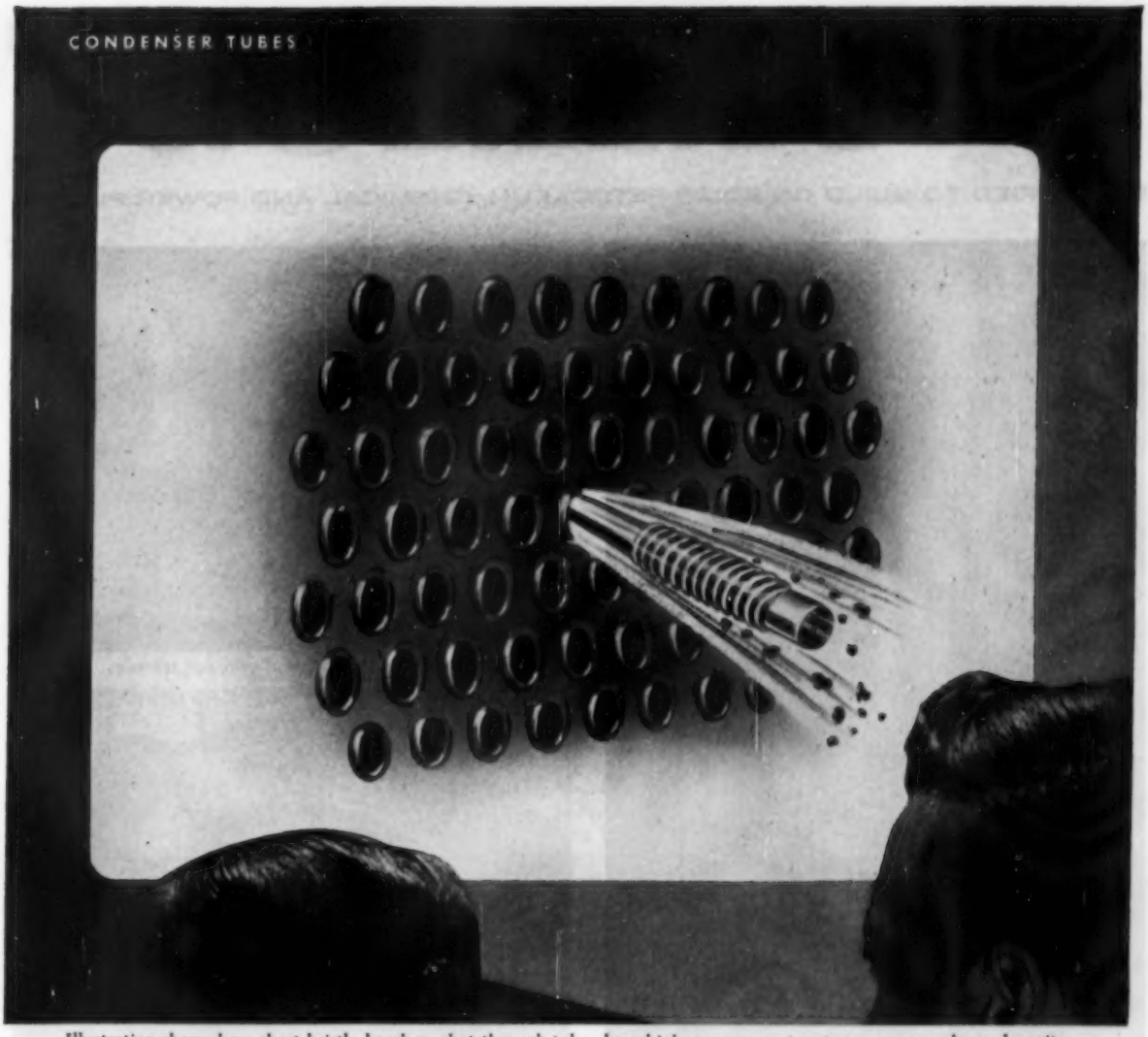

Illustration shows how short bristle brushes—shot through tubes by a high-pressure water stream—remove loose deposits.

COOLING WATER: how its composition affects life of condenser tubes

You can't always pick your plant site where water is noncorrosive. Economics may not permit it. If your plant is located inland, cooling waters generally will be relatively noncorrosive. Tide water plants, however, will have corrosion problems, particularly if the sea water is polluted with industrial or domestic wastes. This is especially true if the organic matter in the sewage is able to ferment under anaerobic conditions. Then sulfides are likely to form. In an enclosed harbor or in a dead-end channel, water may be more or less stagnant. There it is particularly subject to infestation by anaerobic bacteria.

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Is Poor Health Really the Price of Success?

No, declares the author, who studied the incidence of stress diseases among 700 senior and junior executives.

Dr. Allan J. Fleming,
E. I. du Pont de Nemours & Company
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THE HOLLYWOOD version of the big executive invariably portrays him in a lather of activity, such as carrying on a three-way phone conversation between Yokohama, Istanbul, and Troy, N. Y., all the while barking orders to a bevy of remarkably good-looking secretaries, whose beauty is overshadowed only by their extraordinary efficiency. He makes snap decisions without difficulty, and apparently without thought. It is not unusual for him to breakfast in New York, have cocktails in London, and dinner in Paris on the same day. The five-hour differential in time does not appear to upset the conditioned reflexes of his gastronomic system in the slightest way.

According to the popular magazines of the read-it-in-two-minutes, forget-it-in-ten-minutes type, this sort of an executive is prone to develop ulcers, high blood pressure, coronary heart disease, or some other manifestation of stress.

But Does He?—What are the facts about stress disease, and is it true that executives are especially susceptible? Perhaps we should elaborate on the term executive. Dr. George L. Bach, dean of the Graduate School of Industrial Administration, Carnegie Institute of Technology, says there is no such thing as an ideal executive, but there are some qualities that set aside really first rate executives from the much larger number of solid reliable, but not outstanding, business men.

These qualities he lists as follows:

- The orderly ability to size up problems and reach action decisions on the best facts available.
- The ability to deal effectively with people and get people to work effectively toward a common goal.
- The instinctive acceptance of responsibility.
- A thorough understanding of the inter-relations between his business and the economic, social, and political forces of the entire environment.
- The imagination to sense what is fundamental in the rapid change of modern industry and modern society. No human trait is more common than to do what seems comfortable, accustomed, and secure. The executive who tries to keep on building buggies in the air age—or who insists "the way I learned to do it is the best way"—is commoner than many of us like to admit. In a world moving at the devastating pace of today, merely doing yesterday's job better today, is failure.

To the foregoing we may add as a corollary to No. 2, a good executive must have a well-developed sense of fairness. In addition, he should know how to delegate responsibility to others.

We may suppose that if an executive possessed all of the above qualities he could handle any situation that might arise without subjecting his physiological make-up to stress of any kind. On the other hand, if a man is endowed with too few of the qualities that go to make up a good executive, he may be prone to develop stress disease if he is repeatedly thrust into situations where he cannot avoid emotional and physical wear and tear. Square pegs do not fit in round holes, and a good lieutenant may not make a good colonel.

An executive, above all else, is called on daily to make decisions. He is obliged to consider how these decisions will affect his superiors, his colleagues, and those he must supervise. Rarely are these decisions rendered without emotion of some kind, whether it be apprehension, fear, anger, resentment, or doubt. The degree to which his internal environment is upset by the physiological changes incident to these emotions will represent the physiological stress to which he is subject.

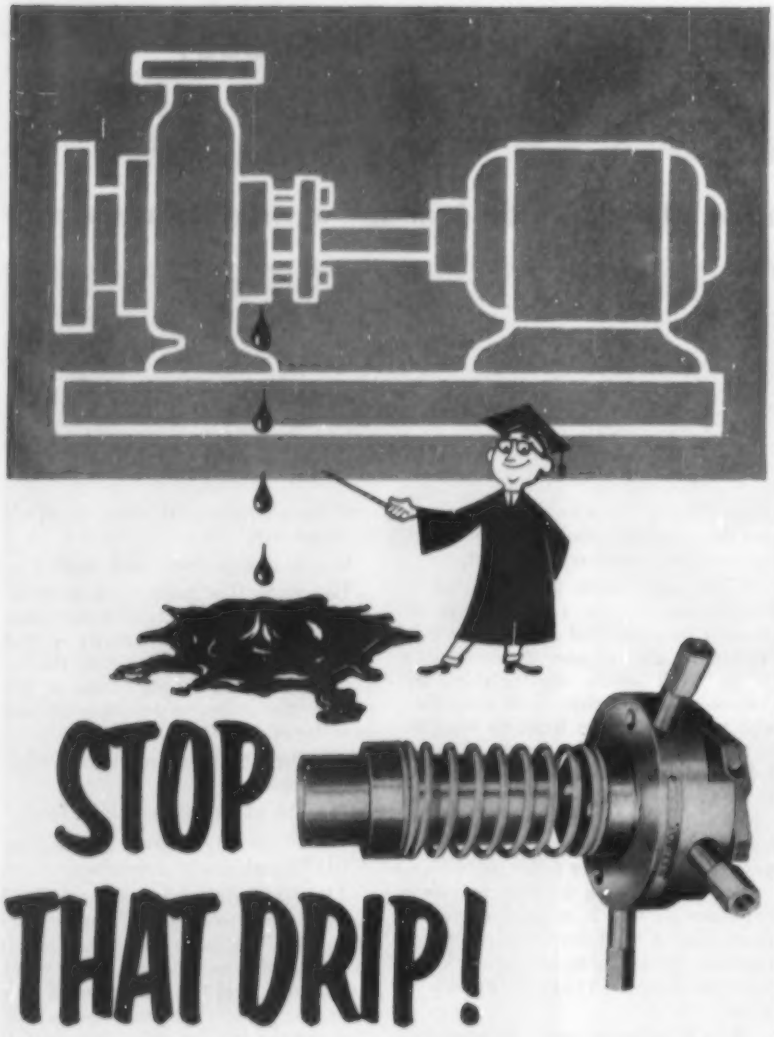
How may this stress show itself?

To answer this question, it is necessary to consider briefly how our emotions may modify the activity of our internal organs. Away back in the beginning of time, simple forms of life such as the primitive ameba possessed four functions:

(a) The ability to react to a stimulus
(b) The ability to assimilate food
(c) The ability to move
(d) The ability to reproduce.

All that evolution has accomplished during successive ages of animal development has been in specialization of each of these four functions of living cells, and the delegation of specific functions to certain tissues. Life was simple for the primitive ameba. Carried along in a warm friendly stream of water, it responded to a stimulus by assimilating the stimulator (if such happened to be food), or by withdrawal if the stimulus was harmful. It was quite unconcerned with its environment or destiny, and spent its time devouring the delicious tidbits that floated its way, or in reproducing republicans or democrats according to the laws of pure chance. The only disturbing part of this glorious round of festive gaiety was the risk that some larger neighbor would come along and gobble it up. It was this ever present threat of "a quick end" that triggered the evolution of a nervous system as an aid to survival of the animal in times of danger.

In Pre-Ulcerous Times—Initially, this nervous system was a simple reflex mechanism where a noxious stimulus is followed by withdrawal of the part affected. (An example of this mechanism in humans is when contact of the hand with a lighted cigarette



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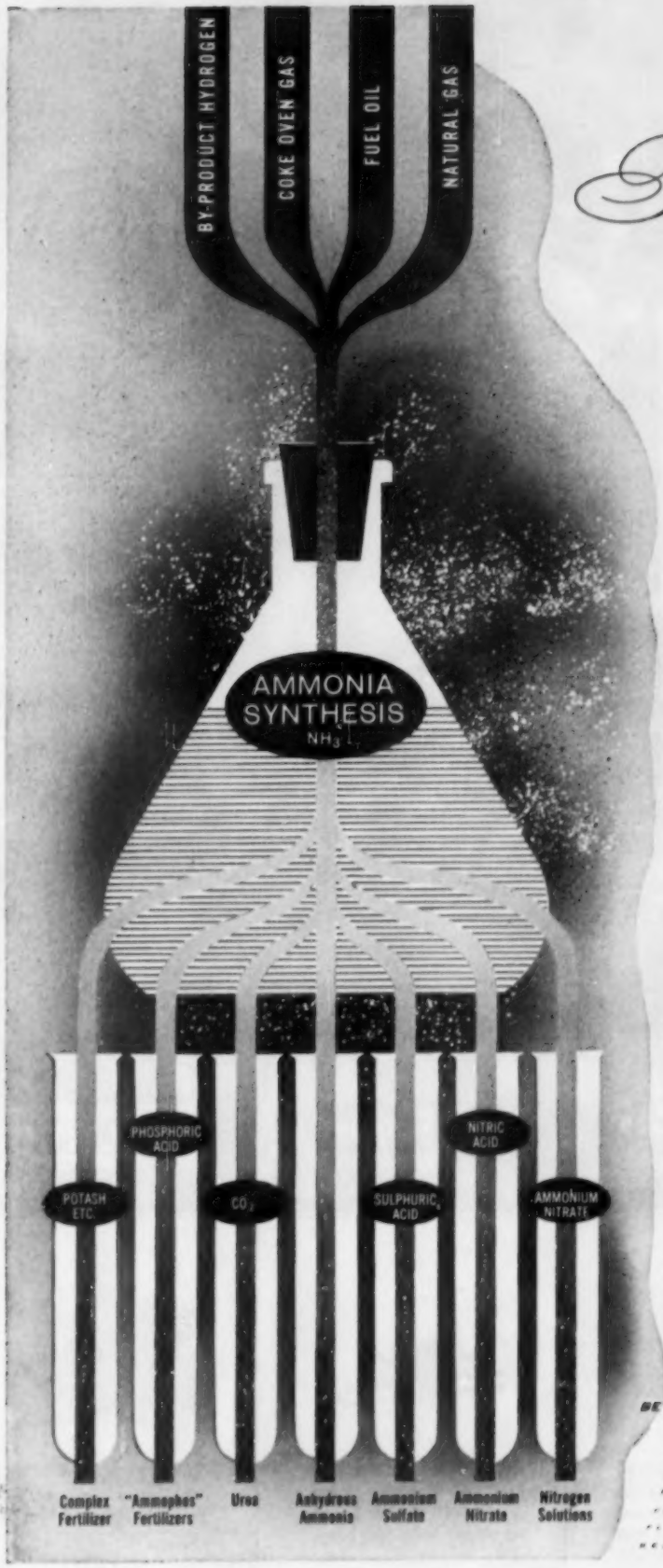
causes the hand to be jerked away automatically. An impulse is sent up a sensory nerve to the spinal cord and relayed back immediately through a motor nerve to activate muscles needed to withdraw the hand. (This all happens before the higher-centers of the brain are aware of the burn). Later, in animal evolution, a primitive brain developed to co-ordinate the function of the muscles so that primitive marine animals could move in a more orderly fashion. The transition of animals from water to land was followed by tremendous changes in the structure and function of certain organs with further specialization of tissues. This transition gave rise to:

- A need for different means of locomotion, resulting in the formation of limbs.
- The need for improved means of defense or offense, and the search for food resulted in a great improvement in existing sense organs. The short-sighted eye of the fish was replaced by one favoring distant vision. The sense of smell and hearing also became adapted to an air environment.
- The replacement of gills by a lung structure for breathing and enclosure of the latter in the thoracic cavity.
- The need to control the amount and composition of the body fluids.
- The development of special glands to moisten and lubricate dry foods so as to aid swallowing.
- Special methods of protecting the young (egg shell—uterine protection).
- Temperature control—feathers, hair, vasomotor reaction to prevent or increase heat loss (sweating, panting, shivering, etc.).

These changes required a great increase in the nerve cells and association tracts of the primitive brain to record and correlate the multitude of new sensory stimuli necessary for the protection and survival of the animal in times of danger. This primitive brain was essential for the formation of conditioned reflexes and the instictive reactions. *More important, it provided the trigger action that sets off the intense organic activity associated with the fight or flight mechanism necessary for the animal's preservation in dangerous situations.* One single sensory stimulus, such as the sight or smell of an enemy, could set off a mass reaction that simultaneously prepared every organ necessary for the animal's defense. This primitive brain persists in all higher animals.



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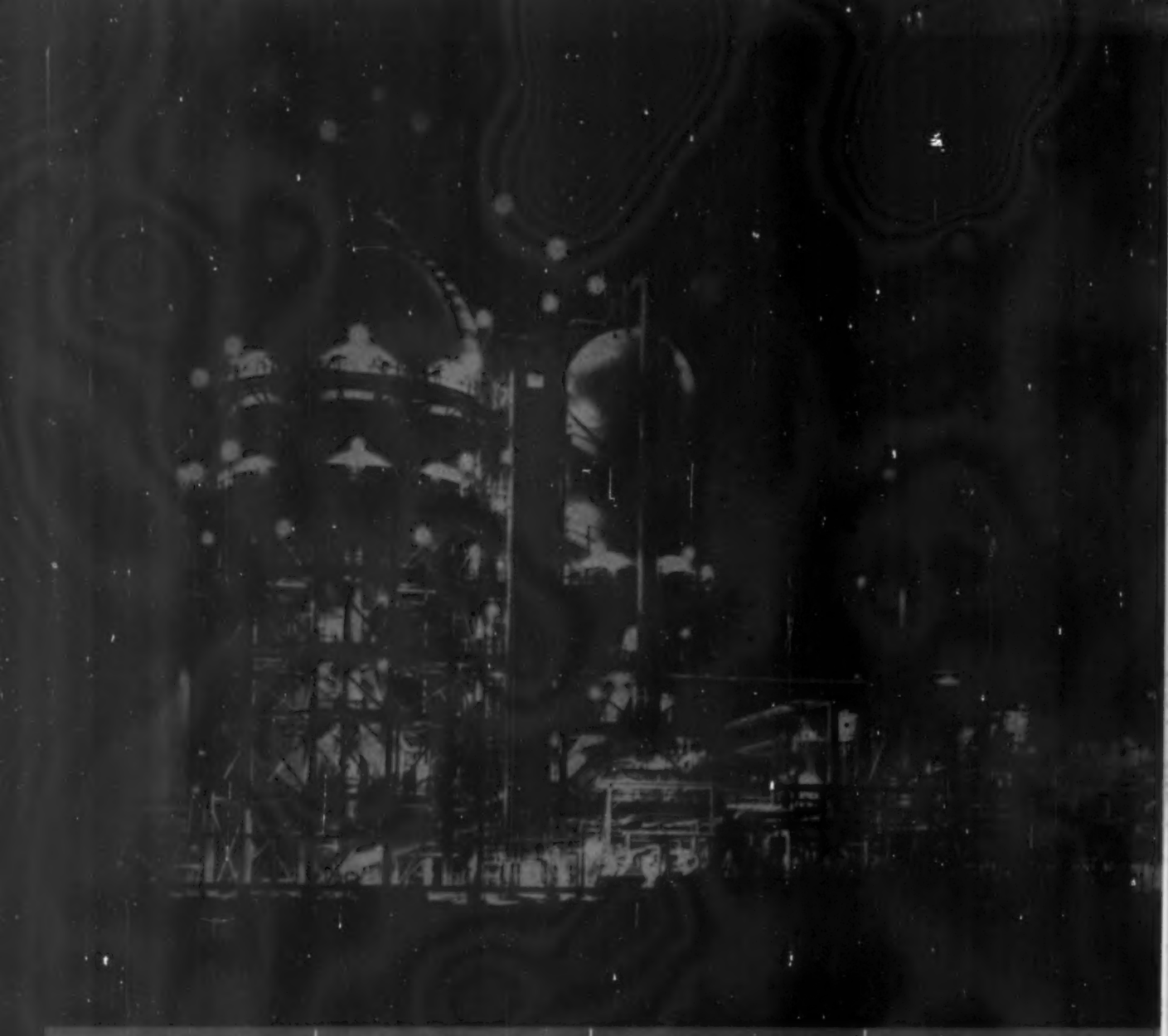

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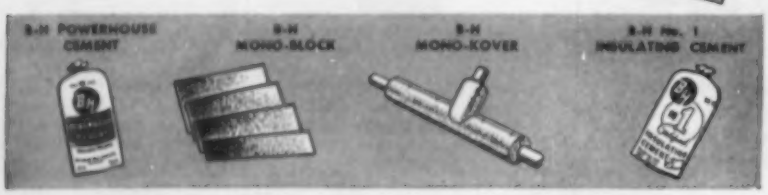

As Management Sees It . . .

forming the thalamus and hypothalamus in the adult human brain. The importance of this area is that in humans it still retains its function in setting off the complex body reactions present in the fight or flight mechanism of lower animals. These physiological reactions in humans give rise to the feelings or emotions associated with fear, rage, anger, hate, love, or jealousy. Under the stimulus of fear or anger, this trigger action of the hypothalamus causes the pupil of the eye to dilate. The flow of saliva stops, and the mouth becomes dry. Blood vessels contract and the blood pressure rises. The sphincters of the stomach contract and the secretion of gastric juice is greatly decreased. The adrenal glands secrete adrenalin. The motility of the small and large intestine is inhibited.

It is clear from the foregoing that any disease or emotional disorder that will stimulate this primitive area in the brain in an abnormal way will give rise to overactivity in some internal organs and underactivity of other such as occurs during the primitive emotion of fear or anger.

For the most part in modern civilization, we humans do not need such an elaborate system for our defense against physical aggression. The developmental tie-up between the cerebral and vegetative part of our nervous system appears at times, to be a bit of a nuisance, since we cannot dissociate our cerebral activity from our visceral activity due to the inherent structure of our nervous system. The sensory control mechanism in the hypothalamus often interferes with our ability to reason by impressing its feeling tone on our higher centers. The reverse is also true, and many of the distressing, annoying, petty, of no account-fears, rages, jealousies or other disturbing impressions associated with our social, moral or business life, may bombard the hypothalamus in such a way as to keep our insides in a constant state of turmoil.

We do not know why chronic stress affects the arteries and blood pressure of one individual or the stomach or duodenum of another. We do know that under stress the individual has no voluntary control of the changes produced in his internal environment and, therefore, is unable to prevent stress disease from developing by conscious effort.

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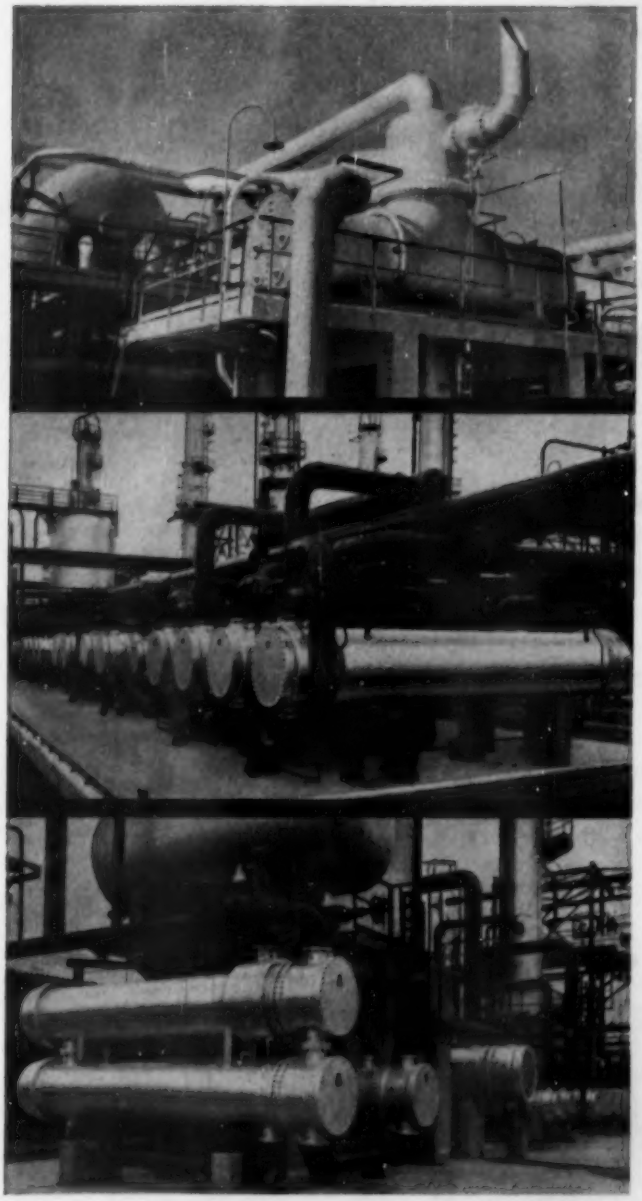

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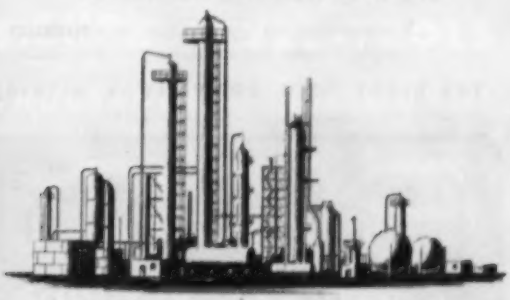

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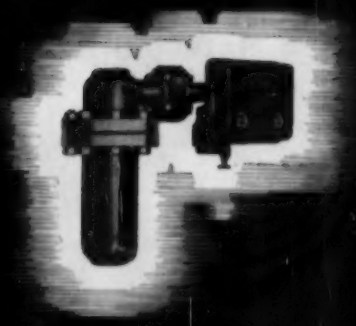
competition, a wobbly dollar, and a paternalistic government. Coupled to all these difficulties, executives are bound to have a sense of individual frustration and resentment at the lack of reward for extraordinary effort. No matter how an industry may try, there is no way under the present tax laws that real executive ability can be compensated financially.

Pressure and Disease—We now come to the question—has the pressure of private (and community) business, and the mode of living of the modern executive rendered him more susceptible to stress disease such as: peptic ulcer, high blood pressure, coronary heart disease, or psychoneurosis? Dr. Louis J. Dublin, vice president and statistician of Metropolitan Life Insurance Company, believes there is no sound basis for the often repeated statement the coronary heart disease is more prevalent in executives.

Our experience bears this out for coronary disease as well as for other so-called stress disease. We studied the incidence of stress disease in some 700 senior and junior executives in our company. The factors we looked for were the occurrence of hypertension, mild (diastolic pressure 90-99), moderate (diastolic pressure 100-109), and severe (diastolic pressure 110 or over); secondly, the occurrence of coronary heart disease as shown by electrocardiographic changes, and lastly, by the occurrence of peptic ulcers. The fourth manifestation of stress, such as psychoneurosis, was so minor, or so unmeasurable in this group, as to be of no importance.

We concluded from our study that this group of executives on the whole were no different from the general run of employes, as far as the occurrence of stress disease is concerned. The sales group of executives, however, did show a minor, but statistically significant increase in the number of hypertensives.

Possibly these findings are not in accord with the findings of other companies who have adequate medical records. Dr. Robert C. Page, Medical Director of Standard Oil Company (N. J.), feels that there is a definite increase in the incidence of peptic ulcers and hypertension in executives he has studied medically. More studies in which executive groups are compared with non-executive groups are needed to provide the final answer. It is possible the popular belief that executives are more prone to things like coronary heart disease is influenced by the inevitable publicity at-



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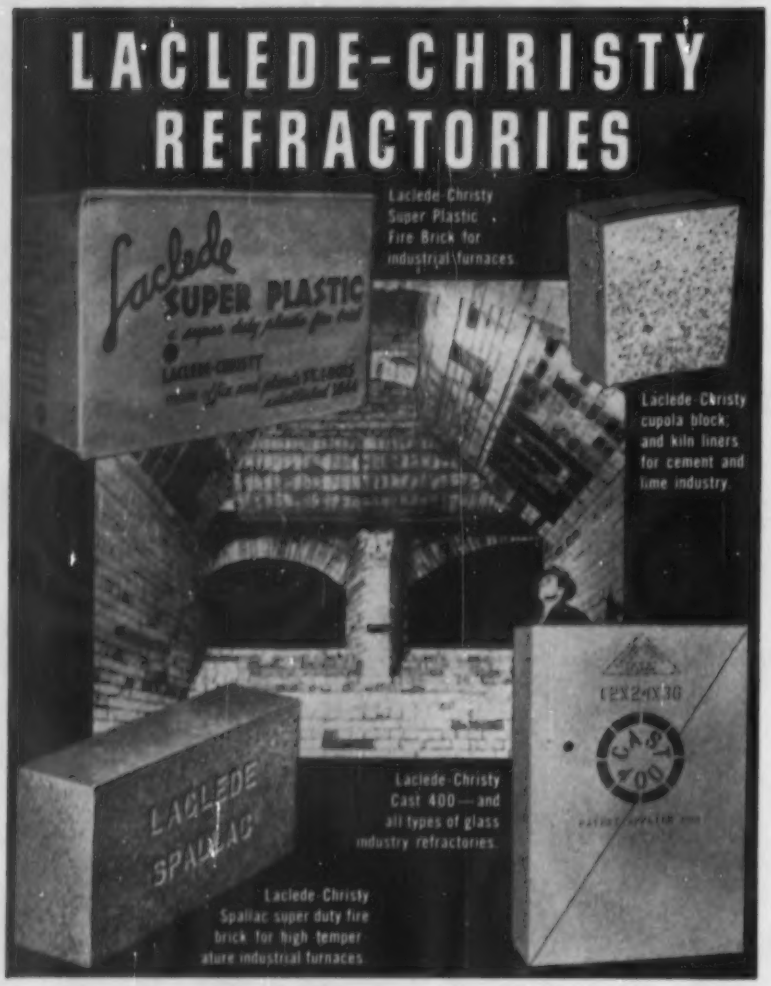
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As Management Sees It . . .

tending the premature death of a prominent executive from heart disease, while no one remarks when the unobstrusive little fellow around the corner slips away from the same disease. Until sound data to the contrary appears on the horizon, we will continue to assure prospective executives that their chances of developing stress disease on an occupational basis, if they move up the administrative ladder, are in no way increased. ##

Quantity of New Scientists Only One Phase of Problem

A new facet to the problem of assuring a sufficient flow of scientific manpower from the nation's colleges was pointed out by Alan T. Waterman, director of the National Science Foundation, speaking before the House Subcommittee on Educational Activities of the Federal Government.

From the long-range view the greater concern should be over quality rather than quantity, said Dr. Waterman. While a serious problem exists now in the lack of sufficient scientific manpower, the year 1954 represents the low point in college graduations, reflecting the low birth rate at the depth of the great depression. From now on, he said, the number of graduations is expected to increase. By the 1960's, when children born in the 1940's graduate from college, there is expected to be a doubling in the output of college graduates.

"The task before us in maintaining the quality of training of this great increase in enrollments is one of the most serious problems facing us in maintaining economic and defensive strength," he declared.

Dr. Waterman pointed to the necessity for assuring a sufficient number of teachers and for improving scientific instruction in the secondary schools and in many of our colleges and universities.

As an indication of the nation's present manpower potential, Dr. Waterman quoted recent statistics showing that fewer than half of the top quarter of high school graduates now complete college. While economic factors may play a part in this situation, he stated that lack of adequate motivation to continue advanced training is also a major factor ##

Johns-Manville announces the development of new SIL-O-CEL 16L *Insulating Fire Brick . . .*

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Combines outstanding physical and thermal properties for furnace service to 1600F

Check these properties of SIL-O-CEL 16L

Maximum service temperature	1600F, back-up or exposed
Approximate density	33-35 lb per cu ft
Transverse strength	60 psi
Cold crushing strength	350 psi
Linear shrinkage	0.7 percent at 1600F
Reversible thermal expansion	less than 0.1 percent at 1600F
Thermal conductivity (Btu in. per sq ft per F per hr at indicated mean temperatures)	0.92 at 500F 1.07 at 1000F 1.22 at 1500F

1—has less than 0.1% reversible thermal expansion at 1600F

2—provides high load-bearing strength

3—for direct exposure or back-up service

Here is a new development of Johns-Manville insulation and refractory research. Its exceptional characteristics provide important savings in furnace construction. Made of diatomaceous silica, Sil-O-Cel* 16L Insulating Brick is light in weight . . . has low thermal conductivity . . . high structural strength. And where furnace linings are subjected to severe heat shock or where high load-bearing properties are needed, Sil-O-Cel 16L offers outstanding performance.

Sil-O-Cel 16L is now available. Samples will be sent on request. Also available without obligation is Booklet IN-115A, which describes Sil-O-Cel 16L and other J-M Insulating Brick and Insulating Fire Brick for service to 3000F. Write Johns-Manville, Box 60, New York 16, N.Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Sil-O-Cel is a Johns-Manville registered trade mark

Replaces SIL-O-CEL Natural Brick

The development of Sil-O-Cel 16L Insulating Brick has resulted in the discontinuance of Sil-O-Cel Natural Brick. The outstanding properties of Sil-O-Cel 16L make it the ideal replacement for Sil-O-Cel Natural Brick for back-up use. In addition, the properties of Sil-O-Cel 16L Brick extend its use to exposed service applications.

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MATERIALS · ENGINEERING · APPLICATION

Tailor Your Training Program

Here are 27 approaches to the problem of executive training. Some of them will fit your needs—once you decide what these needs are.

W. C. Eldridge,
Booz, Allen & Hamilton
Los Angeles

WHAT ARE corporations doing to develop their executives?

Seven years ago the National Industrial conference Board decided to get answers to this question. It discovered there were not enough programs to form the basis for a report. When it tried again in 1949 it found plenty of companies with strong programs.

Significant among its findings was the fact that no two companies approached executive training the same way. The NICB report listed 20 different training techniques and to these we have added seven more that are used to some extent. As an indication of the prevalence of these 27 techniques, they are grouped on a popularity basis:

There are five that appear in practically all company programs:

1. Merit or performance reviews.
2. Visits to other companies.
3. Attendance at technical meetings and management conferences.
4. Distribution of reading lists and Management Bulletins.
5. Group meetings.

Here are six more that are often used:

6. Job rotation.
7. Advanced management courses, at universities.
8. Consultants.
9. Committee assignments.
10. Executive inventories.
11. Job descriptions.

There is another group of nine that are sometimes used:

12. Special trainee positions.
13. Multiple management plans.
14. Management cabinets.
15. Understudy or assistant-to positions.
16. Community leadership.
17. Health and fitness programs.
18. Individual counseling.
19. Assignment to training or sales department.
20. Sponsor plans.

In addition to these 20 there are seven more that are different to a degree:

1. Problem solving.
2. Role playing.
3. Job observation.
4. Training tours.
5. Luncheon groups.
6. Public speaking.
7. Classes in human relations.

It's very apparent that it would take a lot of analyzing against the particular situation in order to determine which techniques would be most beneficial. Because we are concerned with the development of engineers, let's confine our thinking to the techniques that might be most appropriate for them.

To start out, we should know what attributes we are trying to build. The changes made in the curricula of the engineering schools are good clues to the shortcomings they detected in their graduates of the '20s and '30s.

They have in effect said they need broadening and to learn how to get along with people. Notwithstanding this opinion, the big corporations with executive development programs say they make no distinctions for their engineers. This does not mean that they think the extrovert salesman and the introvert engineer need the same guidance in the handling of people, for example. There is reason to suspect that they are finding their executive development job big enough without tailoring the program to the specific needs of functional groups. Also there is the possibility of undiplomatic implications.

For the executive or company that is willing to tailor a program to the specific needs of engineers here are a few of the undeveloped "flat sides" frequently found in engineers as a group.

First, and probably most important, with their training in logic and high regard for facts, engineers are inclined to expect individuals and situations to be governed by reason. Actually, the psychologists tell us man's motivation is emotional most of the time. Consequently, the engineer needs to know more about leading and handling people.

Second, engineers are a superior group intellectually and they are likely to show impatience over the degree of understanding and work pace of others. They can become very unpopular in the process.

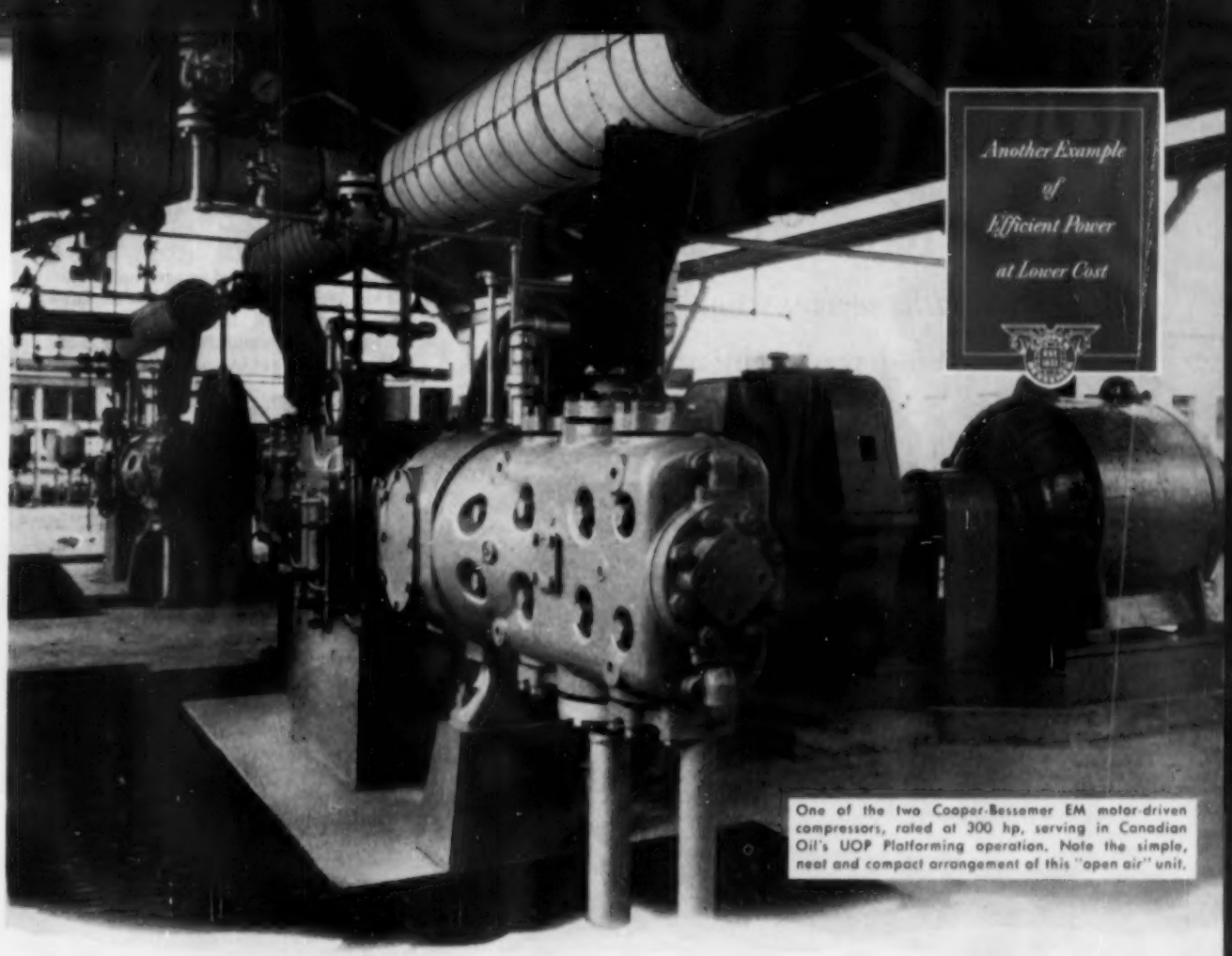
Third, engineers are inclined to have narrow interests. They seem to concentrate on their chosen field to a degree that dwarfs the other functions of the business in their mind.

A minor point, in terms of ease of correction, is the overuse of technical terms—the jargon of a specific field of work. In conversation with other executives, the use of technical abbreviations and slang terms can be most disconcerting.

Now for some of the techniques that may prove particularly applicable to them.

First, there are performance reviews and individual programs. We employ a great number of engineers in our own organization. All of them must be of management caliber because they are dealing with top management problems most of the time. We do conduct monthly staff development round table discussions. However, the absorption rate varies with the individual and his progress is not measurable from these sessions alone.

More effective from the individual development standpoint are the performance reviews conducted after every assignment. In these the man is rated on every element involved in good all-round performance and future progress. After two or three reviews the engineer knows his flat sides and has lost much of his sensitivity about them. He has discussed what he must



One of the two Cooper-Bessemer EM motor-driven compressors, rated at 300 hp, serving in Canadian Oil's UOP Platforming operation. Note the simple, neat and compact arrangement of this "open air" unit.

With CANADIAN OIL'S PLATFORMING UNIT... a new high in compressor efficiency for high octane gasoline

COOPER-BESSEMER 2-cylinder motor-driven M-Line compressors efficiently recycle hydrogen for the UOP Platforming unit in the Sarnia, Ontario, refinery of Canadian Oil Refineries, Ltd.

Cooper-Bessemer developed compressors with non-lubricated cylinders have permitted Canadian Oil Refineries to run its Platforming unit thousands of hours without any possibility of contaminating the recycle gas with lubricating oil.

Canadian Oil's Platformer is charging nearly 3800 barrels per stream day, and producing high yields of gasoline with an octane number reaching well into the 90's. In this process, Cooper-Bessemer EM's continue to play a vital and dependable role in the production of high octane gasoline.

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Oil company reports

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The centrifugal pumps at Bray Oil Company of Los Angeles handle at different times alcohol, caustic, lime solution, acid sludge and dry solvent. The pumps are steam cleaned between usages of these different commodities. Under these tough service conditions ordinary pump packings last only 2 to 3 days; either the shaft or sleeve had to be replaced every 6 months. Ed Jones, maintenance superintendent at Bray, reports that currently LATTICE BRAID Teflon packing has given over 10 months service, *and no* shaft or sleeve replacement has been necessary in that time!

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

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GARLOCK LATTICE BRAID PACKING

As Management Sees It . . .

do to correct them and subsequent reviews clearly tell him and his superior what sort of progress he is making. Every few months a fresh look is taken and additional suggestions made. This technique permits you to know the man much better, measures his progress, determines his readiness. Most important it gives you a sound reading on his character and will power which in the last analysis determine how much of his development program he actually can accomplish.

Against the inadequacy in handling people, we can consider those techniques with people as a common denominator. These include group meetings, involving active participation in discussions, and committee assignments, in which the committee is made up of men from the other functions of the business.

Multiple management plans, management cabinets, junior boards of directors and similar devices serve to broaden as well as improve relationships with other people.

Formal schooling is a useful technique, although it is not company tailored or controlled.

In putting several techniques together they probably should be so balanced that they cover three aspects of the job:

- Recognition of what improvement is required, by both management and the individual engineer.
- Programming over an adequate period of time to produce results, and
- Practice of what is learned in situations where assistance and constructive criticism can be provided.

With the heavy demand for engineers without business experience and the increasing requirement for engineering backgrounds in management, it certainly looks as if the seasoned engineer with management potentialities is a very precious item in your personnel inventory. How do you protect your "investment"? The full answer to this question is a subject for another day. It should be apparent, however, that you should, as a minimum program, conduct a job evaluation analysis to be certain that your engineers are being compensated adequately and equitably in terms of other positions within your organization and similar positions outside your organization.

Acknowledgment: This article is from a paper, "The Executive Development of Engineers," presented at the 28th Annual Fall Meeting of the California Natural Gasoline Association.

FOAMGLAS®

the cellular, stay-dry insulation

Insulation Contractor: Combustion Equipment & Insulation Co., Cleveland, Ohio

SOHIO gets efficient desalting because . . .

Spillage-proof FOAMGLAS insulation stays effective to hold precise temperature

Efficient electric desalting to remove salts and other impurities from crude charging stocks demands precise temperature control throughout the process. The influent temperature (180° F to 220° F depending on viscosity of crude) must be held constant until effluence. Since there's no exchange of heat inside the sphere, it must be insulated very effectively.

For six years Standard Oil Company (Ohio) has maintained peak desalting efficiency by insulating their spheres in Cleveland, Lima and Toledo with FOAMGLAS. This unique cellular glass insulation benefits SOHIO three ways:

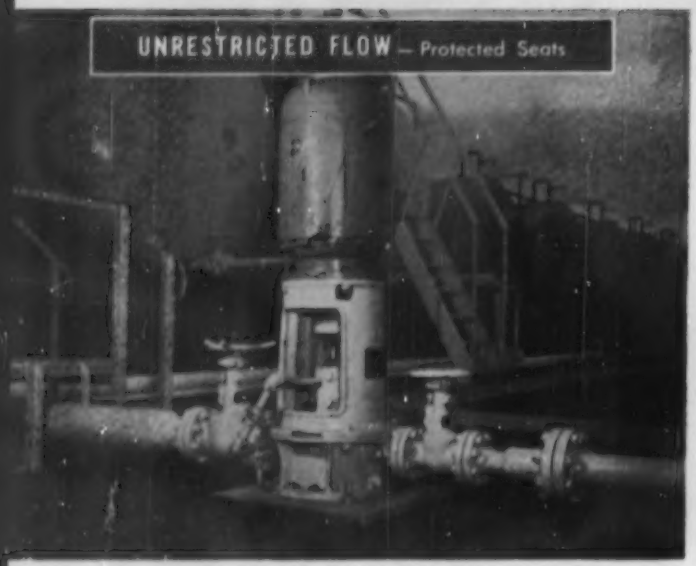
1. **Spillage-proof,** moisture-proof FOAMGLAS retains its insulating value . . . avoids fire hazard.
2. **Easy-to-apply** FOAMGLAS blocks are lightweight but very strong, readily applied to sphere, eliminating insulation supports.
3. **Effective insulation** holds temperature required for electric field to break continuously the water and oil emulsion. It also prevents temperature drop near vessel wall . . . avoids thermal currents which would interfere with process.

You'll benefit too by using this unique insulation. For more facts please write for booklets on FOAMGLAS for piping or tanks and equipment.

Pittsburgh Corning Corporation
Dept. Z-15, One Gateway Center
Pittsburgh 22, Pennsylvania
In Canada: 57 Bloor St. W., Toronto, Ontario

2" thick FOAMGLAS blocks cut to 12 x 12 size were laid diamond shape on SOHIO'S desalter sphere in Toledo. Two Nelson studs were welded through each block and secured with recessed Tinnerman speed clips. After asphalt cutback (Insulmastic 4010)—glass fabric—cutback application, the surface was finished with an asphalt base aluminum paint.

Look Where ORBIT VALVES . .



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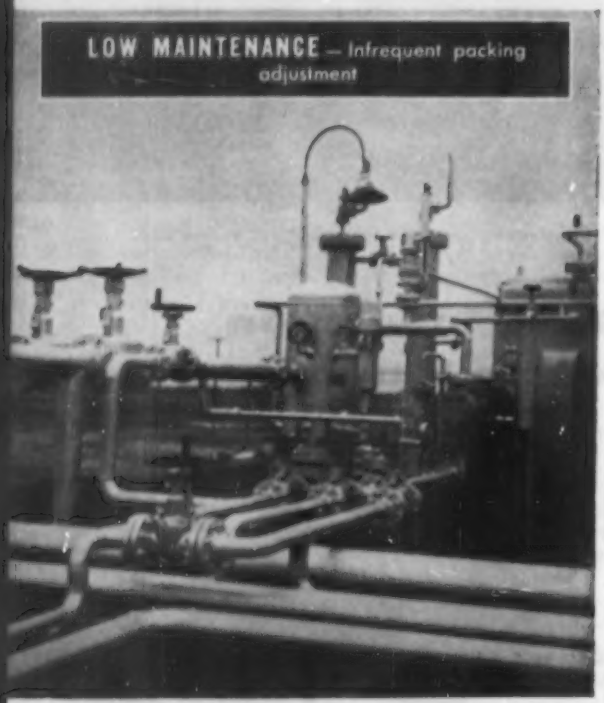
LP-Gas Loading Pump Manifold. Fluids cannot be trapped in the valve body either open or closed. Another Orbit safety feature.



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ORBIT *forged steel* A.S.A. Class VALVES offer many more advantages. Besides being a modern streamlined valve that is compact in design yet rugged, it is competitively priced and meets A.S.A. face to face specifications. No lubricant is required to effect a seal thus ORBIT forged steel valves require an absolute minimum of expense and attention. Contraction, expansion or vibration will not cause the seating surface to separate in the closed position.

ORBIT *forged steel* A.S.A. Class VALVES are offered equipped with two distinctly different body seats at no extra cost to the customer. Our Buna-stainless Type "B" body seat is recommended for handling aliphatic hydrocarbons, aliphatic alcohols, anhydrous ammonia, water, salt water, crude oil, vegetable oil and animal oils. Our Type "C" stainless-

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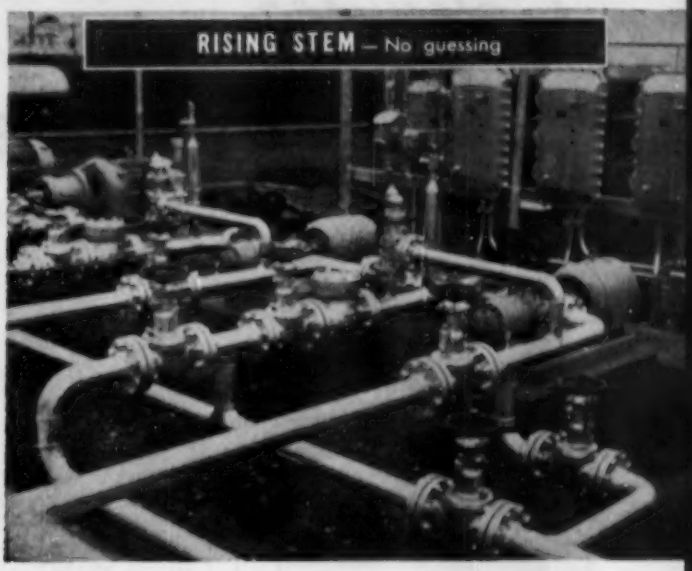
Iso-Butane Coolers. Valves must work when needed. Orbit Valves friction free core and seating provide ease of operating and no sticking.

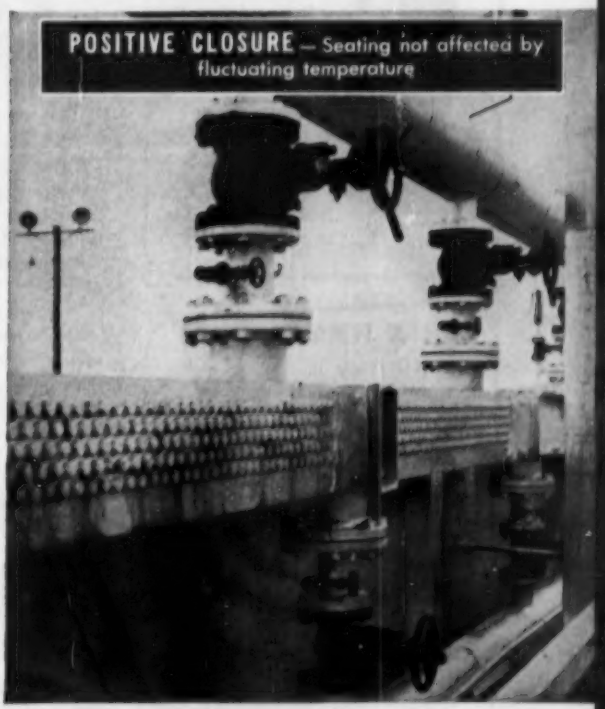


Suction & Discharge — Propane & Water Lines. Mistakes can be costly. The Orbit rising stem feature shows at a glance whether the valve is opened or closed.

. About ORBIT VALVES

asbestos body seat is also recommended for the above services plus aromatic hydrocarbons, chlorinated hydrocarbons, esters, aldehydes, amines, aromatic alcohols, ketones, ether, anhydrous ammonia, salt water, water. *If possible please specify service when ordering or write us for further detailed recommendations.*

ORBIT *forged steel* A.S.A. Class VALVES are rated 250° Fahrenheit maximum working temperatures. Sizes: 2″, 2½″, 3″ and 4″, 300 lb., 600 lb., 900 lb., 1500 lb., 2500 lb. A.S.A. Class screw or flanged end. Venturi Orbit Valves are offered in 150 lb. class, sizes 2″, 2½″, 3″ and 4″. 300 lb. class size 6″ only. 600 lb. class size 6″ only. 1½″ and 2″ are offered in 1500 and 2500 lb. class. All sizes listed furnished in either carbon or stainless trim.



De-Iso Butanizer Overhead Condenser. The Orbit Valve resilient seating principal insures positive closure even though temperature changes may occur.

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As Management Sees It . . .

Now Try the Dynamic Merit Increase

Are you dissatisfied with the employe incentive your dollars have bought? Here is a plan for rewarding real merit, for discarding "tips for tenure" practice.

F. Roe Weise,
Standard Oil Company (Indiana)
Chicago

SO YOU ARE dissatisfied with the employe incentive your dollars have bought. . . . Perhaps you have tried profit-sharing and found it isn't the whole answer, especially for large groups. Maybe you have used production bonuses with some success in hourly-paid operations, but found the practice unworkable among those you want most to reach—the white-collar men such as supervisors, chemists, engineers and clerks.

But have you tried the dynamic merit increase?

This may solve your problem. But it must be properly administered.

Improperly planned, it can stultify ambition, promote complacence. Regular pay hikes in small amounts without regard for merit have no part in the dynamic merit increase plan. They are only "tips for tenure."

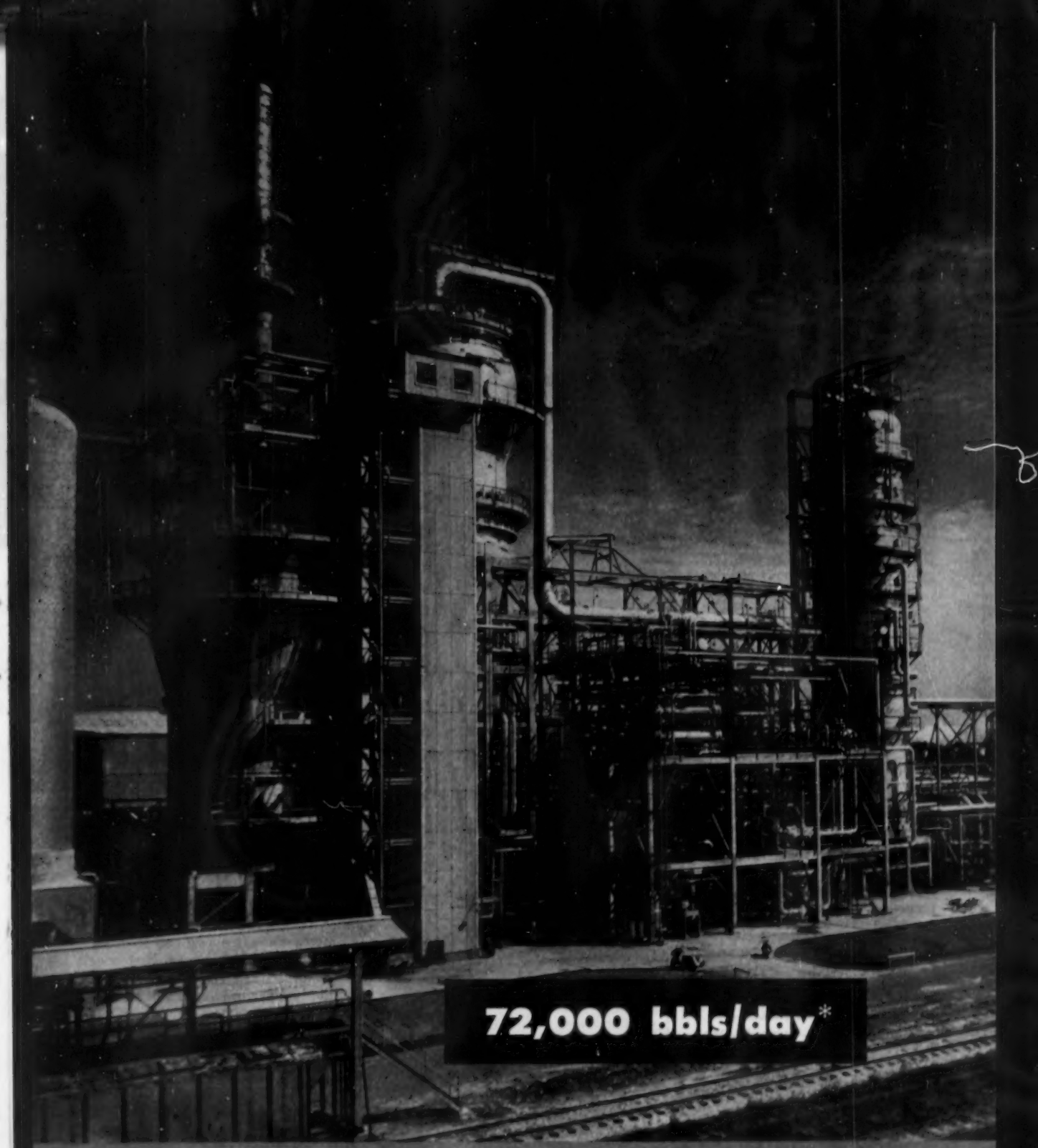
Unearned Security—In following this practice it has been customary to make a review for merit increase purposes about Christmas time and award the increases effective January 1. Perhaps the Christmas spirit has something to do with it, but generally it is felt that the more people rewarded, the better the "morale." This leads, then, to widespread increases in small amounts. It disregards real merit. Almost the only ones who do not receive increases are those who are about to be fired. This, of course, creates a feeling of unearned security—a feeling of expectancy once every year. It proves to the average or sub-average employe that his work does not need improvement. He gets salary increases simply for being on the payroll. Each year he gets a "tip for tenure."

Then, too, a merit increase does little good if it is not accompanied by an explanation as to why it is being given and what can be done to merit the next one. What incentive is created at the time a merit increase is not given if no explanation is made as to why the increase is being withheld? Furthermore, a false feeling of well-being results if an employe is led to feel that the level of his present salary is never in jeopardy; that under no circumstances will his employer reduce it even if his performance falls off. This produces a loss in incentive. An employe should understand that he must earn his salary to receive it.

On the other side of the coin, the manner of administering merit increases can be dynamic. The practices that are followed must be designed so that employes will be impelled to give more work and better work in exchange for the payroll dollar.

In the first place, it is necessary to devise some way of judging whether a man's work has been good, bad, or indifferent. This means that there must be some kind of standards, against which performance on similar jobs can be compared. One of the simple ways to do this is to take the groups of employes doing similar work and build up a scale divided in thirds, the top third for the above-average, the middle third for the average, and the bottom third for the beginners and those who are below-average. When this has been done, it is necessary to slot the individual performance of each employe into the appropriate portion of the scale. Then comes the job of locating the salaries of each employe in the same scale. Is each salary below average, average, or above average? Stated another way, where is each in relation to the usual starting rate for the job, the usual average rate, and the usual top price?

Price Tags—The job of appraising an employe's performance and comparing the performance with the



Now "on stream",—this new Fluid Catalytic Cracking Unit at the Norco, Louisiana refinery of the Shell Oil Company. This unit will process 72,000 barrels per day, including recycle*. Mechanical design, engineering and construction by —

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FOSTER WHEELER

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Case Study No. 103

PORT ARTHUR, TEXAS, REFINERY INCREASES THROUGHPUT

VOLUME IN TOWERS

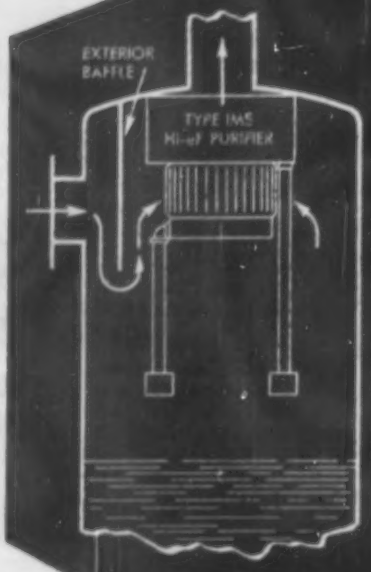
with Hi-eF PURIFIERS

EQUIPMENT REQUIRED:

Two Internal Hi-eF Purifiers (Types IMS-16 and 18) with special outer baffles.

SERVICES:

Large slugs of entrained hydrocarbon liquids were seriously affecting the throughput of these two towers. The problem was further complicated by the fact that the vapor-inlet nozzle was near the outlet which accelerated carryover. Refinery technicians approached entrainment engineers of the V. D. Anderson Company for a solution. Anderson recommended that a Type IMS 16 and a Type IMS 18 Hi-eF Purifier with special external baffles be installed inside the towers at the vapor outlet. The No. 18 Hi-eF Purifier was designed to handle 165,217 #/hr. ethane at 96 PSIA and (—) 40°F, and the No. 16 Hi-eF Purifier handled 93,400 #/hr. propane gas at 31.5 PSIA and 10 deg. F.



RESULTS:

The Hi-eF Purifiers with a special exterior baffle designed by Anderson engineers accomplished their function so efficiently that throughput in the entire process was improved considerably.

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Free!

Write for Bulletins 101 and 401 describing many money-saving applications with Hi-eF Internal Purifiers.

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As Management Sees It . . .

location of the employe's salary is made much easier if there are specified rate ranges or "price tags" for each job. It is also made easier by the use of one of the hundreds of different kinds of employe appraisal systems that are in use in industry today. The job can be done, however, whether these tools are at hand or not. It is a simple process and one which can be done with pretty rough tools.

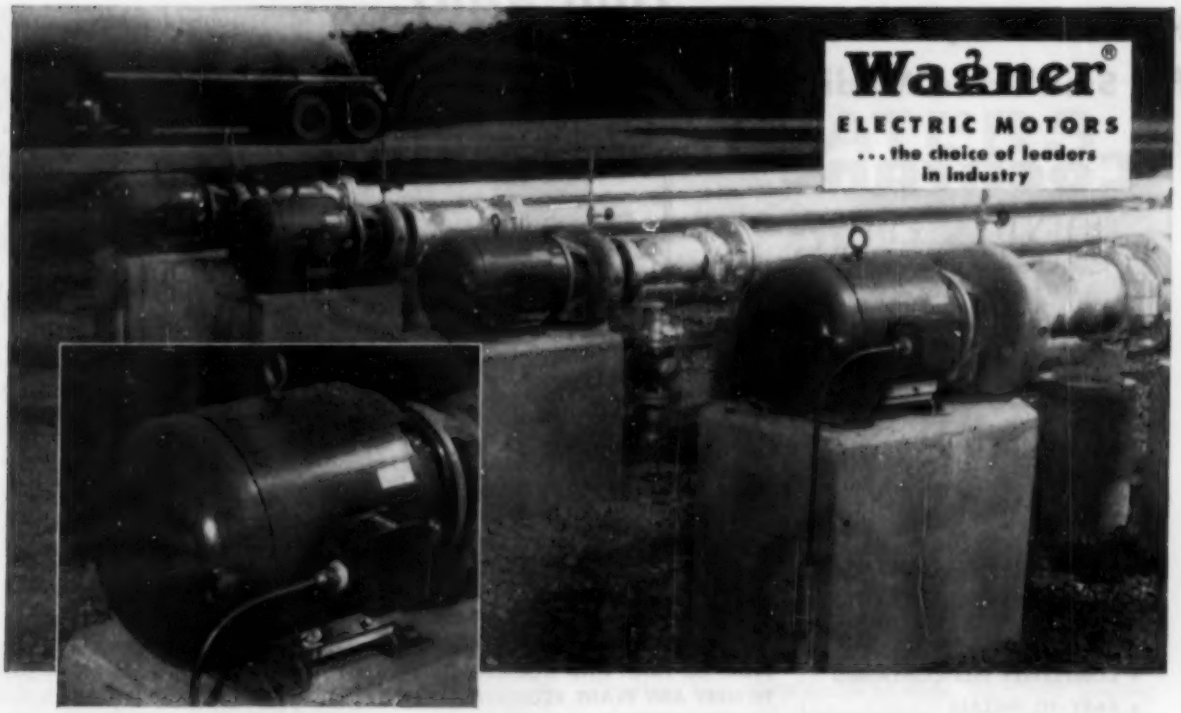
After a review has been made of an employe's performance and a comparison of that performance is made with the location of the employe's present salary, it is then possible to determine whether an employe is presently getting less, as much as, or more than his performance is worth.

If the salary is as much as or more than the employe's performance is worth, he should not receive an increase. If he is getting less than his performance is worth, his salary should be moved toward where it belongs. If he is getting more than his performance is worth he should be given a chance to bring his work up to the level of his salary, and if this does not happen, then his salary should be reduced to the level of his work. This seems so simple and so sound that one is almost tempted not to say it. It is, however, the basic principle of a dynamic merit increase program and, sound and simple as it is, there are probably very few employers adhering to it today.

The general trend has been to reward an employe each year for staying on the job providing his performance is satisfactory. Employers who do this do not pay much attention to the level of the employe's salary in relation to the level of his work performance but feel that, somehow or other, it is "good for morale" to give an increase as often as it can be done, and "bad for morale" not to give one.

Actually, if an employer wants to get the best performance from his employes, if he wants to hold out an incentive for improving the quality and quantity of the salaried employe's work, he will let it be known that an employe will receive what he earns and only what he earns. If he wants to continue to receive it, he must continue to earn it. If he wants to receive more money, he must demonstrate that he is worth more. He must understand that behaving himself and being on the job another year is not enough to warrant his getting a merit increase. He must be worth more than he was worth last year to receive more.

In an establishment where "tips for tenure" has been the rule, a policy



use Wagner Explosion-Proof Motors for *EXTRA PROTECTION* in explosive atmospheres

A single spark in a hazardous atmosphere can cause tremendous explosion and fire damage in less time that it takes to tell.

Motors that operate in explosive atmospheres must be absolutely non-hazardous as far as spark or flame are concerned. Wagner Explosion-Proof Motors qualify perfectly for such applications. That's why these Wagner Motors are the time-tested favorites of the petroleum industry—in the field and in the refinery. They are approved by Underwriters Laboratories for Class 1 Group D hazardous locations.

Wagner also manufactures a line of drip-proof 40° motors, polyphase or single-phase, especially designed for the continuous outdoor service demanded by oil well pumping applications.

Write for Bulletin MU-137 on Oil Well Pumping Motors and for Bulletin MU-185 on the complete Wagner Motor line. Thirty-two branch offices are ready to assist you in any motor application problem.

The externally mounted blower, which cools the motor, is made of non-sparking bronze.
Housings are strong enough to successfully withstand the explosion of flammable substances inside the motor.
Sealed conduit box, constructed to prevent the escape of flames, is tightly held together by four bolts. It has a threaded opening for rigid conduit connection.
Endplates are fastened with eight clamping bolts—double the usual number.
Endplates are extra strong, to withstand internal explosions, and have machined fits long enough to prevent the escape of flames to the surrounding atmosphere.
Wagner Explosion-proof Motors have heat capacity great enough to prevent the motor (even under abnormal operating conditions) from reaching a temperature which could ignite surrounding gases.

Wagner Electric Corporation EST. 1891

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TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

M55-9

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High Efficiency Deaeration at LOW COST for Small and Medium-Size Power Plants

Cochrane
UNI-PAC DEAERATOR

- FACTORY ASSEMBLED
- COMPLETELY SELF-CONTAINED
- EASY TO INSTALL
- MINIMUM PIPING REQUIRED
- WIDE RANGE OF HEATER SECTIONS, STORAGE TANK AND ACCESSORIES TO MEET ANY PLANT REQUIREMENT
- GUARANTEED ZERO OXYGEN

Here's the deaerator every small, medium-size or even large plant with medium feedwater requirements has been waiting for!

Now for the first time you can get a ready-to-install deaerator that will give you high quality boiler feedwater at extremely low cost. The UNI-PAC DEAERATOR is guaranteed to deliver water with an oxygen content not to exceed 0.005 c.c. per litre (less than 7 p.p. billion)—generally recognized as zero oxygen!

The UNI-PAC DEAERATOR is designed for both right and left hand installation, and in a wide range of outlet and storage capacities. Accessory equipment is available to meet the conditions of operations peculiar to the plant and to obtain the results desired.

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Continuous Blow-Off • Specialties • C-B Systems

As Management Sees It . . .

such as has been described here will come as quite a shock. This shock, though, does not necessarily tear down morale. It can be handled so it can increase it. But the start is difficult, the educational process is a hard one, and the change cannot be made overnight.

Explain the Program—It would probably be well to announce to the supervisors, and by them to the employes, that new tests will be applied in giving merit increases; that the total spent on merit increases each year will not change much with the change in policy; that the individual increases may be larger; that increases may be less frequent, and the percentage of the employes who receive them substantially smaller.

The next step in the procedure is to discuss with each employe his present status, pointing out to each where his salary now is in relation to where it should be. On a case-by-case basis, tell each employe what he needs to do to earn more money. In some cases this simply means that the employe needs only to continue to progress in the manner that he has in the past. Others will have to do specific things to bring their production up to the point where they can receive more money. Another group will have to improve in specific ways in order that they may continue to receive the salary they are now receiving. Still others are receiving and earning the top price for their jobs and they will have to be told that they will have to continue their stellar performance if they are to continue to receive the top price. They will also be told what the possibilities of promotion to the next higher job are and what each needs to do to prepare himself for that eventuality.

On the occasion of the next salary review, a decision will be made in the case of each employe as to what kind of progress he has made since the policy was started. In some cases, an employe will have shown marked improvement and he should be told so and should be rewarded with an increase commensurate with the improvement. In some cases, an employe will have made no improvement, but if his salary is below the level of his performance, he still is entitled to and should receive an increase. If his salary is at the level of his performance, he should receive no increase. If his salary is demonstrably higher than the level of his performance, he should first be warned and given an opportunity to bring his work up in line

A Struthers Wells Type CV absorption oil heater installed at a gasoline plant of one of the largest gas transmission companies, the third installation for this company.

Struthers Wells FIRED HEATERS

FOR

PETROLEUM REFINING

GASOLINE PLANTS

CHEMICAL PLANTS

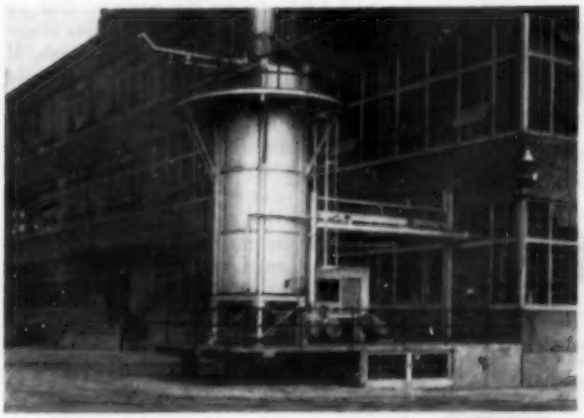
GENERAL INDUSTRIAL USE

Available in standard sizes from 500,000 to 40,000,000 BTU per hour

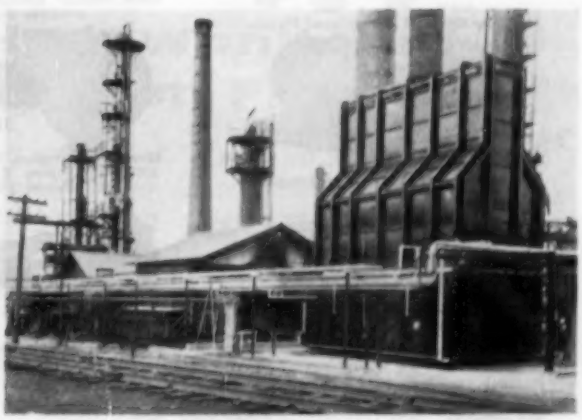
Hundreds of Struthers Wells fired heaters are now in service, in a wide range of sizes, for direct heating of petroleum oil, hydrocarbon gases, asphalt, air, oxygen, hydrogen and superheating steam, and for indirect heating using circulating heat transfer mediums. Circulating fluids used include molten metal, molten salt, Dowtherm, mineral oil, and a number of other organic materials.

In connection with heating systems, we can supply all equipment items, as a complete unit, including wired and piped panel control boards.

We also supply electrically heated units—and special heating and cooling equipment, including water heaters.



A fired heater for Struthers Wells Dowtherm heating system, one of two units installed in a new chemical plant for the production of vat dyes.



Shown above are two Struthers Wells heaters in petroleum refinery service. At right is a three-coil heater used in catalytic reforming of gasoline. At left is a heater which was installed over 23 years ago, and is still in continuous service.

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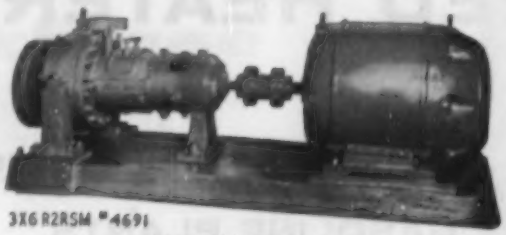
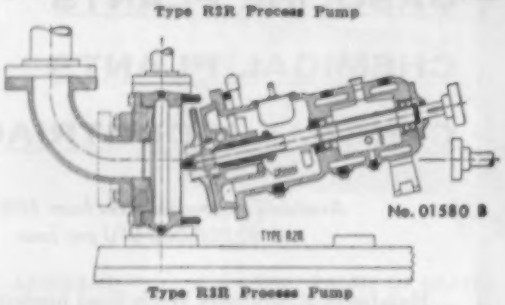
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R3R Process Pump



Type R3R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R3R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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CENTRIFUGAL and RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

4043 AA
Pedestal Mounted Centrifugal Pump

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

4728
Double Pedestal Bearing Centrifugal Pump

3556
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

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with his salary level. If he does not, he should receive a reduction in salary.

If sufficient care is to be taken to analyze properly each employe's performance, and enough time is to be spent to counsel carefully with each employe, it becomes obvious that it is impractical to continue to review the entire payroll and make all of the adjustments at the same time. The Christmas review followed by the January 1 increases will have to be changed to some other basis. This means that the group must be divided up and one-quarter of them handled each quarter, or one-twelfth of them handled each month, or one fifty-second of them each week. One of the most satisfactory ways to do this is to handle the analysis, the review, and the discussion on some anniversary basis. This can be the anniversary of the employe's birth, the anniversary of employment, or the anniversary of the last promotion. There are some advantages in the last of these three since an employe promoted or demoted from one job to another usually receives a promotional increase or a demotional decrease at that time. He then has a year to demonstrate progress before his situation is reviewed again for salary purposes.

No Unearned Security—Summarizing this whole matter, it can be said that what is advocated here is the abandonment of mass merit increases, or "tips for tenure," and to substitute in its place a genuine merit increase program. This merit increase program will be based on the premise that an employe paid on a salary basis is entitled to receive what he is worth. If he is worth more, he should be paid more. If he is worth less, he should be paid less. This involves a new freedom in the giving of liberal increases when warranted and making demerit decreases when they are clearly called for. It focuses the attention of the employe on the fact that he must earn what he gets and must continue to earn it if he is to continue to get it. It practically forces a careful review and discussion of the status of each employe at least once a year. It also forces the presentation of the justification for whatever action is taken in a face-to-face discussion with the employe. It will change the merit increase program from one which gives unearned security to one which is a dynamic thing. It should effect very substantial improvements in employe attitude, employe performance, and the quality and quantity of the work performed in exchange for the

For more data on advertised products, use Readers' Service Cards, last page.

Oil, Abrasion, Heat Won't Hurt Remarkable Petrochem Fire Hose

Here's a fire hose that was specifically designed for the oil industry—Petrochem . . . absolutely oil-resistant, inside and out. It has many other advantages, too . . . it's 50% lighter, yet takes 50% more pressure than conventional, oil-resistant fire hose. It's so flexible that it can be tied in knots without damage. It can be easily coiled or folded for minimum storage. Petrochem is strong and abrasion-resistant . . . will give superlative performance under any refinery conditions, for pressures up to 500 pounds and temperatures up to 300°F.

Tube is of Neoprene . . . jacket of Dacron yarn, impregnated with black Neoprene . . . means complete oil-resistance, inside or out.

We also manufacture a complete line of industrial rubber products: belting, hose, packing and moulded rubber of every construction for every need. *Through your Quaker and Quaker Pioneer distributor* our research and engineering services are always available to help you solve any industrial rubber problem. *Write for free folder and name of nearest distributor.*

QUAKER RUBBER CORPORATION
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QUAKER PIONEER RUBBER MILLS
San Francisco 7, California

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To combat contamination . . .

UNION OIL USES HAMER

Main pump house manifold at Union Oil's Wilmington refinery uses hundreds of Hamer Line Blind Valves.

HAMER *Visible Shut-off* LINE BLIND VALVES

HAMER *Plug Valves*

Custom-crafted, Hamer Plugs welcome the tough applications where ordinary plug valves fall short. Standard dimensions. Readily installed.

With literally hundreds of different hydrocarbons moving through the refinery, Union Oil can't possibly risk product contamination. That's why they use Hamer Line Blinds. Hamer Line Blind Valves not only provide a permanent, positive leakproof shut-off, but are unsurpassed for long service-life and lasting safety. In addition Hamer Line Blinds are fast, simple to operate. One man can open or blind a line in one minute. Costly down time is reduced. Operational efficiency is vastly increased.

HAMER

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Representatives throughout the World

As Management Sees It . . .

payroll dollar.

The opinions expressed in this article are those of the author and do not necessarily reflect the opinions of his company. ##

All Forms of Energy, Atomic Included, Needed for Future

Atomic energy will not displace oil as a source of energy in the foreseeable future, says R. G. Follis, chairman of the board of Standard Oil Company of California.

On the contrary, states Follis, man's needs for energy from all sources will be so great that presently known forms of energy, including atomic energy, will be hard-pressed to meet demands.

Follis' conclusion is expressed in "Oil and the Atom," an article in the Standard of California *Bulletin*, probing into the question, "What will atomic energy do to the petroleum industry?"

"Like all predictions, no matter how well founded in research, these conclusions are subject to the uncertainties of the future," writes Follis.

"(But) It seems to us that even when allowing for more rapid development of atomic power than is contemplated by the best informed on this subject, the principal problem of the oil industry will be to expand its resources sufficiently to keep up with growing demand."

Quoting top authorities on the subject, the article continues:

"The figures tell the story . . . population is growing rapidly. By the year 2000, the world will have a billion more inhabitants. Add to this boom the fact that demand for energy grows even faster than population, and our prospective power requirements in the next half-century reach even higher."

So far as civilian markets are concerned, explains the *Bulletin*, oil and nuclear fuel will be competitors only in the field of power generation. By 1975 the atom may supply 15 percent of this market, but by then the market itself will have doubled.

"The conclusion that nuclear energy can have only a minor effect, if any, on the petroleum market is underscored further by the fact that power generation now represents only 3 percent of the total oil demand in the U. S.," adds the writer. ##

11 ALL-IMPORTANT FACTORS WHICH DETERMINE THE VALUE AND EFFICIENCY OF PROCESSING FURNACES

✔**UNIFORM HEAT DISTRIBUTION**
MAXIMUM FUEL EFFICIENCY
PLENUM CHAMBERS FOR HAZARDOUS AREAS
SIMPLICITY OF DESIGN AND CONSTRUCTION
EXCESS DRAFT FOR HIGH OVERLOAD
EXPLOSION RESISTANT
MINIMUM GROUND SPACE
SHORT LENGTH OF LIQUID TRAVEL
ZERO AIR LEAKAGE
LOW PRESSURE DROP
LOW MAINTENANCE

✔**UNIFORM HEAT DISTRIBUTION** the most desirable heater characteristic is created in an Iso-Flow furnace by:

1. Individual burners are so spaced in relationship to the heating elements that they create a symmetrical flame pattern with relation to the tubes;

2. The metal cone at the top of the combustion chamber re-radiates to the tubes, also diverts combustion gases progressively closer to the tubes to give a uniform heat intensity at the upper portion of the combustion chamber;

3. The combustion gases, at the top of the heater, are diverted towards the walls where they recirculate from the top of the heater downward, behind and between the tubes, increasing the heat input to the rear of the heating elements by convection;

4. The recirculated gases reduce the heat intensity at the bottom of the furnace so that the heat input is the same, top and bottom.

These factors provide the completely uniform heat distribution required in heaters for the most efficient process operation.

In every case where these 11 all-important design characteristics were employed to compare one type of furnace design with another, PETROCHEM-ISOFLOW FURNACES *were proved most efficient by any comparison.*

Prove PETROCHEM-ISOFLOW FURNACES Most Efficient by Any Comparison

More than 1200 PETROCHEM-ISOFLOW FURNACES *are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petrochem-Isoflow Furnaces are pre-eminently satisfactory.*

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 East 42nd St., New York 17, N. Y.

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Above: 150,000-cu. ft. Horton Vaporsphere built for the Sunset Oil Company at Torrance, California.

HORTON VAPORSPHERE

The Horton Vaporsphere® is ideal as the central storage unit of a vapor conservation system. Interconnected by large diameter vapor piping to fixed roof tanks storing volatile hydrocarbons, the Vaporsphere provides temporary storage facilities for vapor displaced by thermal expansion or filling operations.

The Vaporsphere is a spherical steel shell with a flexible hemispherical membrane on the inside that is attached to the shell at the equator. The space below the membrane is used to store the vapor when it is displaced from interconnected tanks. When conditions causing the displacement are reversed, the vapor returns to the tanks.

Further information, estimates or quotations on a Horton Vaporsphere may be obtained by writing our nearest office. There is no obligation on your part.

Above: Cutaway view of Horton Vaporsphere showing interior details.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3	Healey Building	Detroit 26	Lafayette Building	Pittsburgh 19	Alcoa Building
Birmingham 1	North Fiftieth Street	Houston 2	C & I Life Building	Salt Lake City 4	West 17th South Street
Boston 10	201 Devonshire Street	Los Angeles 17	General Petroleum Building	San Francisco 4	200 Bush Street
Chicago 4	McCormick Building	New York 6	165 Broadway Building	Seattle 1	Henry Building
Cleveland 15	Midland Building	Philadelphia 3	1700 Walnut Street Building	Tulsa 3	Hunt Building

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Chicago Bridge & Iron Company Ltd., Apartado 1348, Caracas, Venezuela
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Horton Steel Works Limited, Fort Erie, Ontario, Canada
Motherwell Bridge & Engineering Company, Motherwell, Scotland
Whessoe, Limited, Darlington, England
Comprimo N. V., 21, Amstel, Amsterdam (C) Netherlands

What's Happening in the Industry . . .

Lyman Predicts Rise in Research and Development

American industry will invest about $2,750,000,000 in research and development this year—6 to 7 percent more than in 1954, A. L. Lyman, president of California Research Corporation, predicted last month.

His estimate was delivered before the Conference on Scientific Manpower, held at Berkeley, Calif., as a part of the annual meeting of the American Association for the Advancement of Science.

About $850,000,000 of the total represents industrial research underwritten by the federal government and the remainder covers private programs, Lyman said. His figures were based on a special survey conducted by Cal Research, a subsidiary of Standard Oil Company of California. More than 120 large and small manufacturing concerns were included in the study.

Industry's planned outlay for 1955 represents a four-fold increase over research spending in 1941, Lyman disclosed.

Monterey Buys Fullerton For $50 Million in Cash

Monterey Oil Company has purchased all oil and gas properties, gasoline plants and other assets of Fullerton Oil and Gas Corporation for a cash consideration of $50 million.

Earlier last year, Fullerton, formerly Fullerton Oil Company, was purchased by Albin Corporation and Church Oil and Gas Company with funds partially supplied by Monterey. Monterey has now purchased Fullerton from Albin and Church at their costs plus expense.

Fullerton has three natural gasoline plants and properties which will increase Monterey's net daily production by 5700 barrels of crude oil, 3800 barrels of natural gasoline and liquefied petroleum products, 475 Mmcf of dry gas, and 18 Mmcf of plant residue gas. Fullerton's activities will continue uninterrupted. Its officers, key employes and other personnel will be added to the Monterey organization.

Jersey Standard Head Sees 1955 a Good Year

The year 1954 was looked upon in a favorable light in the petroleum industry, Eugene Holman, chairman of the board of Standard Oil Company (New Jersey), said last month in a year-end statement. Moreover, he said, business in the coming year is expected to show continued progress.

Holman noted that world demand for petroleum products reached a record high in 1954, increasing almost 2 percent in the U. S. and more than 9 percent abroad. In 1955, he commented, Jersey Standard economists expect domestic consumption to increase by about 5 percent and foreign consumption nearly 7 percent over 1954.

"Prospects for the new year are bright," he said. "The outlook is for continued economic progress in the free world."

Jersey Gives to Medical Fund—

Eugene Holman, seated, chairman of the board of Standard Oil Company (New Jersey), hands a $50,000 check to Colby M. Chester, honorary chairman of the board of General Foods Corporation, for the National Fund for Medical Education. The money, part of Jersey's half-million dollar total 1954 contribution to institutions of higher education, will go to strengthen the teaching and research budgets of the nation's 80 medical schools. Chester is chairman of the Fund's Committee of American Industry.

Synthetic Rubber Plants Sell Fast; Oil Firms Get Big Shares in Early Contracts

Oil companies grabbed off large shares in the first synthetic rubber plants to be sold last month under contract by the Rubber Producing Facilities Disposal Commission.

Sales contracts for the first six plants (there are 27 in all) were as follows:

- Shell Chemical Corporation gets three plants in the Los Angeles area: a copolymer plant operated by Midland Rubber Corporation; a styrene plant run by The Dow Chemical Company, and a petroleum butadiene plant Shell Chemical has been operating.
- Goodrich-Gulf Chemicals and Texas-U.S. Chemical Company have contracted three plants at Port Neches, Texas. The former company, a subsidiary of Gulf Oil Corporation and B. F. Goodrich, will buy a copolymer plant. The Texas Company shares interest with United States Rubber Company in the latter, which will buy another copolymer plant. Both groups, Goodrich-Gulf and Texas-U.S. Chemical, have contracted to buy a half interest each in a butadiene plant.

Deadline for the sale of all 27 plants was to have been midnight December 27. By the Monday after Christmas, the commission announced it had disposed of 24 installations, leaving three to be sold. Synthetic rubber capacity sold up to that time was over 650,000 long tons annually, against a minimum requirement of 500,000 long tons. No prices have been published but authoritative speculation has put the figure over $265 million for the 24 plants.

Contracts signed subsequent to the first contracts included those with these companies:

- Phillips Chemical Corporation signed for butadiene and copolymer plants at Borger, Texas.
- Firestone Tire & Rubber Company contracted for synthetic rubber plants at Akron, Ohio, and Lake Charles, La. Firestone now operates both plants.
- Copolymer Corporation signed a contract for a synthetic rubber plant and a petroleum butadiene plant, both at Baton Rouge, La. Copolymer, current operator of both plants, is owned by six rubber companies and Sears Roebuck & Company.
- Humble Oil & Refining Company contracted for a butyl rubber plant and a butadiene plant, both at Baytown, Texas. Humble currently operates both plants.
- Koppers Company, Inc., signed for an alcohol butadiene plant at Kobuta, Pa., idle since July, 1953.
- Goodyear Synthetic Rubber Corporation contracted for two synthetic rubber plants at Houston and Akron, Ohio. Goodyear Synthetic has been operating both plants.
- American Synthetic Rubber Corporation has contracted to buy a copolymer plant at Louisville, Ky. The plant has been operated by American Synthetic, which is owned by a combine of 29 firms.
- Petroleum Chemicals, Inc., a subsidiary of Continental Oil Company and Cities Service Refining Corporation, has contracted for a butadiene plant

HOUDRIFORMING gives HIGHEST YIELDS in Gasoline Upgrading

Houdriforming licensees:

On stream:
Sun Oil Company, Marcus Hook, Pa.
Sun Oil Company, Ltd., Sarnia, Ont.
Ohio Oil Company, Robinson, Illinois
Petrocarbon Chemicals, Inc., Irving, Texas
Crown Central Petroleum Corporation, Pasadena, Texas

Under construction:
Sun Oil Company, Marcus Hook, Pa.
Ashland Oil and Refining Company, Catlettsburg, Ky.
Commonwealth Oil Refining Company, Puerto Rico
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PROCESS CORPORATION
1528 Walnut Street, Philadelphia 2, Pa.
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PIONEER IN CATALYTIC PROCESSES

Houdriforming catalytic reforming process answers the increasing demand for higher octane motor fuels. Also, this process gives exceptionally high yields of benzene, toluene, and xylenes as well as high octane gasolines and aviation base stocks. Houdriforming is a continuous process, completely flexible.

There are now five Houdriformers on stream, four more are under construction. Among the many features of Houdriforming are longer catalyst life and the restoration of catalyst activity by regeneration *in place*.

Write on your letterhead for a new brochure describing the Houdriforming process.

at Lake Charles, La. Cities Service has been operating the plant.

- Food Machinery & Chemical Corporation has signed for a butadiene plant at Houston, which Sinclair Rubber Company has been operating.
- United States Rubber Company will buy two plants at Naugatuck, Conn., which it now operates. One is a synthetic rubber plant, the other a dodecyl mercaptan (rubber-making chemical) plant.
- Esso Standard Oil Company will get a butyl rubber plant at Baton Rouge, La., which it has been operating.
- Standard Oil Company of California contracted to purchase a petroleum butadiene plant at El Segundo, Calif., which it is currently operating.

All contracts are subject to final congressional approval.

Arrangements Completed On Independents Merger

Another note in the merger movement was sounded last month when H. M. Baskerville, president of Western Oil and Fuel Company, and S. M. Burnap, president of Direct Service Oil Company, announced their respective companies have arranged to merge.

The merged companies would have a substantial interest in International Refineries, Inc., which Baskerville also heads. Entire output of International Refineries' new 10,000-barrel-a-day refinery at Wrenshall, Minn., will be marketed by the merged companies.

Direct Service obtained most of its products supply from this plant last year.

Direct Service will be merged with Western Oil, subject to approval of stockholders, through exchange of stock. Management, personnel, brand names and policies of the companies will be unchanged.

Greeff to Market Products From Brownsville Plant

Stanolind Oil and Gas Company has announced that it has signed an exclusive contract with R. W. Greeff & Company, Inc., New York, for marketing the production of chemicals from Stanolind's chemical plant at Brownsville, Texas.

The Greeff company will act as Stanolind's sales agent for marketing the chemicals from the Brownsville plant, which is expected to begin operations in the fall of 1955. The agreement covers all of the water-soluble chemicals—acids, alcohols, aldehydes and ketones—that will be produced at Brownsville. Design capacity of the Brownsville plant is approximately 125 million pounds of chemicals per year.

The chemicals to be produced at Brownsville originate as by-products of the hydrocarbon synthesis process employed in the Carthage Hydrocol, Inc., gas synthesis plant at Brownsville. The water-soluble chemical stream is piped to Stanolind's adjoining chemical recovery plant, where the chemicals are separated and refined.

Mid-West Elects Director

David Smith, of Edmonton, Alberta, Canada, formerly associated with Superior Oil Company and presently engaged in oil production and exploration in Canada, has been elected to the board of directors of Mid-West Refineries, Inc., of Grand Rapids, Mich.

Area Zoned Where Large Refinery Planned

Commissioners of Newcastle County Levy Court of Delaware have established a general industrial zone in an area near Delaware City where Tide Water Associated Oil Company plans to build a new refinery of 130,000 barrel-a-day capacity.

Tide Water has options on about 4000 acres of land in Red Lion Hundred area near Delaware City.

The commissioners adopted a zoning map setting up a general industrial zone in a corridor splitting two tracts used by King's College, whose officials had sought large buffer zones and a "no industry" zone separating sections of the college's campus.

What's Happening. . .

Gilliland Recipient of AIChE Publication Award

Edwin R. Gilliland, professor of chemical engineering at Massachusetts Institute of Technology, was presented last month the William H. Walker Award of the American Institute of Chemical Engineers.

The Award honors the memory of the late William H. Walker, also a professor at M. I. T. and a pioneer in the modern concept of chemical engineering.

Presentation of the Award was made at

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What's Happening...

the Awards Banquet held during the annual meeting of AIChE in New York last month.

Professor Gilliland, an authority on separation processes and applied industrial chemistry, has been cited for this recognition because of his publication record over the past few years.

Union Oil Expanding Brea Research Center

A million dollar expansion program for the Brea, Calif., research center of Union Oil Company of California is scheduled for completion next fall, the company has announced.

The project will provide facilities for large-scale experimental units, pilot plants, additional laboratories and offices.

Largest of the new units will provide 33,000 square feet of floor space. This all-steel structure will be 65 feet high. Adjacent to this area, to be used for large-scale experiments, pilot plants and laboratories, a second steel building will cover 27,000 square feet for experimental equipment which can be operated out of doors with individual instrument control houses. Two single-story office buildings are also scheduled.

The project stems from Union's decision to concentrate its extensive research and process activities at a single site.

Fischer Will Head SOD Refinery Liaison Office

Standard Oil Development Company has established an Office of Refinery Liaison under Herbert G. M. Fischer, who organized the company's Process division. Fischer will serve as manager while Dr. Roger W. Richardson, formerly associate director of Esso Laboratories at Baton Rouge, La., will be associate manager.

In connection with Dr. Richardson's appointment, a number of executive changes were announced by Esso Laboratories.

Dr. Robert W. Krebs, an assistant director, was promoted to associate director, succeeding Dr. Richardson.

Dr. Lindsey I. Griffin, Jr., Frank B. Johnson and Charles N. Kimberlin were appointed assistant directors, and Dr. Robert E. Wood was named assistant director. These appointments increased the number of assistant directors of the Laboratories from three to five.

Dr. Griffin has been with the Laboratories since 1937, Johnson since 1934, Kimberlin since 1933, and Dr. Wood since 1941.

Texaco Promotes Bonar And Teeters to Aide Posts

George L. Bonar, assistant to the president of The Texas Company, has been named assistant to the chairman of the board, and Hanson D. Teeters, executive assistant in the Finance and Economics department, has been made assistant to vice president.

Bonar became associated with Texaco's Refining department in Tulsa in 1928. He served in various capacities in Houston and New York, becoming assistant to the president in 1952.

Teeters began his service with Texaco in 1928 as credit manager in Los An-

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What's Happening. . .

geles. He was appointed assistant treasurer in 1945 and executive assistant in 1952.

Union Oil Elects Miller

J. W. "Win" Miller has been elected executive vice president and director of Brea Chemicals, wholly owned subsidiary of Union Oil Company of California. Miller is presently manager of Union's southwest marketing territory which includes Southern California, Arizona, New Mexico and Nevada.

Executive Changes Made On Aurora Gasoline Staff

Promotions and appointments have been announced within the executive and managerial staff of Aurora Gasoline Company, of Detroit. They include: L. A. Curran to general manager of refining; P. A. Blasco to assistant manager of refining; Soma Kurtis to director of manufacturing; H. J. Oberding to chief engineer; Donald Albaugh to assistant chief engineer; L. R. Schiff to director of supply and transportation; F. W. Schuessler to traffic manager; Charles Nannes to director of purchases, and W. C. Gleich to manager of crude oil supply.

Standard Oil Development Forms Two New Divisions

Two new major divisions have been established by Standard Oil Development Com-

Tyson Scheeline

pany. They are: the Petroleum Development division, headed by C. Wesley Tyson, and the Chemicals Development division, under the direction of Harold W. Scheeline.

The company, at the same time, appointed Homer Z. Martin director of the Process division and Burton C. Belden associate director of that unit.

The new divisions were created by separation of the old Development division into two distinct groups.

Tyson is presently on a training assignment with Esso Standard Oil Company. During this training period Arnold F. Kaulakis will serve as acting director of the Petroleum Development division. Kaulakis and Henry J. Ogorzaly were also appointed assistant directors.

In another appointment, Stanley E. Jaros, who has been with the company since 1942, was named assistant director of the Chemicals Development division.

Dr. Scheeline has been assistant director of the Development division since 1947. Dr. Martin has served as assistant director of the Research division since last September and was previously assistant director of the Development division. Dr. Belden has been with the company since 1936, Kaulakis since 1942, and Ogorzaly since 1937.

AIME Group Sets Up Award To Honor Cedric Ferguson

The late Cedric K. Ferguson, project leader with the California Research Corporation at La Habra until his death last year, has been named first recipient of the memorial award established in his name by the Petroleum Branch, American Institute of Mining & Metallurgical Engineers.

Ferguson died of polio in August, 1953.

The memorial, a bronze medal bearing Ferguson's name and a bas-relief portrait, was awarded "in recognition of his great promise as a scientist and his outstanding record of participation in community affairs."

Formal presentation of the medal was made to his parents, who are from La Jolla, Calif., by J. B. Alford, Petroleum Branch executive secretary, at the organization's recent fall meeting held in San Antonio.

In the future, the memorial award will be presented annually to a member of the Petroleum Branch under 33 years of age for an outstanding paper in any field of petroleum technology. Selection

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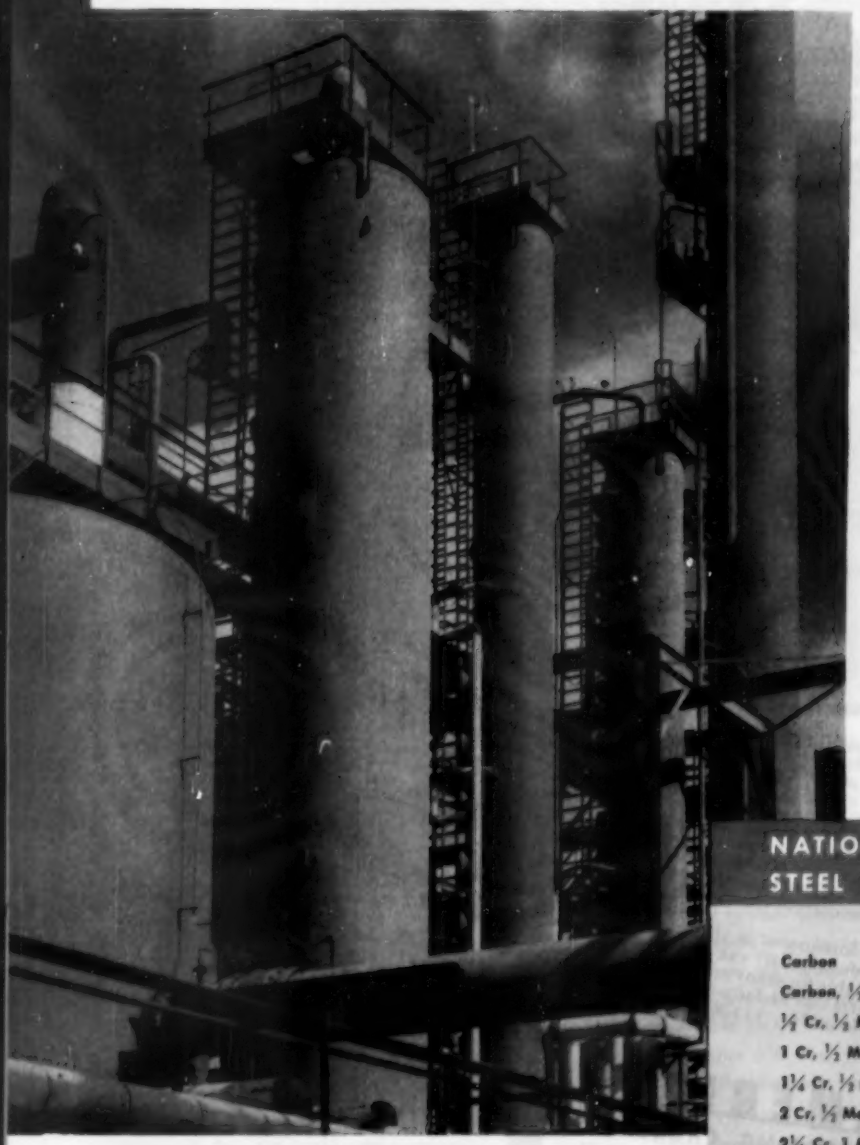

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1¼ Cr, ½ Mo	8 Cr, 1 Mo	25-20
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2¼ Cr, 1 Mo	12 Cr	5 Ni
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What's Happening. . .

will be made by a committee of AIME petroleum members.

Tide Water Sets Aside Funds for Refinery Work

More than $60 million has been marked for refinery building and modernization in the 1955 spending program of Tide Water Associated Oil Company.

Much of this sum will be used to start construction of a major refinery on the eastern seaboard. Designed for a capacity of 130,000 barrels a day, the new plant will replace Tide Water's Bayonne refinery.

Tide Water Shuts Down Old Watson Refinery

The Watson, Calif., refinery of Tide Water Associated Oil Company was closed this month because it is obsolete.

"Refining facilities at the 30-year-old plant have become outdated and too small in capacity for economical operation," T. L. Wark, vice president and Western division manager of Tide Water, said. "Consequently, its job will be taken over for the present by the Avon Flying A refinery."

Tide Water is about to place a 10,000-barrel-a-day Platformer on stream at the Avon refinery. Tankage at Watson will be kept in service as a terminal for products available from Avon and elsewhere.

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Porter Says Oil Picture Improved; Urges Caution

The petroleum industry is in a considerably stronger position at the end of 1954 than it was at the beginning of the year, and even stronger than during the late summer, Frank M. Porter, president of the American Petroleum Institute, said late last month. Main reason for the improvement, according to Porter, was the working off "to an extent" of the inventory excesses on hand when the year opened.

Porter, in an end-of-the-year statement, characterized the year 1954 as one of conflicting and difficult pressures for the petroleum industry. Demand for products was disappointing, and less than forecast, he said, but the use of petroleum will nevertheless establish the twelfth annual consecutive gain, showing perhaps 1.5 to 2 percent greater demand than in 1953, when final returns are in.

Even though demand rose moderately in 1954, domestic crude oil production declined. The amount of crude oil processed in refineries fell off also, with a comparable decrease in the output of key products such as motor fuel, residual fuel and kerosine. Porter reported that domestic production appeared to be on the upgrade again but indicated that the situation is still one in which caution is advisable, particularly with respect to the relationship of crude oil runs to stills of refineries, relative product yields, the demand for fuel oils this winter and for gasoline in next summer's high-consuming season.

In addition to the slackening in consumer demand, other factors contributing to 1954's slower pace in domestic industry, according to Porter, were: a substantial decrease in exports, the post-Korean decline in military requirements, and the modest slump experienced in general business activities.

Other principal statistics for 1954 reported by Porter included:

Operable refining capacity—8,379,000 barrels daily, up approximately 372,000 barrels.

Crude runs to stills—2,531,000,000 barrels, down 24 million barrels.

Output of refining products included—motor fuel, 1,265,000,000 barrels, down 2,000,000; distillate fuel oil, 538,000,000 barrels, up 10,000,000; residual fuel oil, 415,000,000 barrels, down 34,000,000; total fuel oil, 953,000,000 barrels, down 24,000,000; and kerosine, 122,000,000 barrels, down 825,000.

Five Get New Posts in Changes at Sun Refinery

Several appointments have been announced at the Marcus Hook, Pa., refinery of Sun Oil Company. They include: John S. Thompson, superintendent, coordination; C. Calvin Naylor, superintendent, operations; A. Earle Creamer, superintendent, blendings and packaging; W. Harlan Taylor, assistant superintendent, blending and packaging, and William A. Casey, assistant to the refinery manager.

Thompson has served as superintendent of Sun's Marcus Hook refinery since August, 1952. Naylor became assistant to the refinery manager last March. Creamer has been serving as assistant superintendent in charge of blending and packaging. Since October, 1954, Taylor has been serving as operating assistant, Blending and Packaging division. Casey's previous assignment was as manager of the

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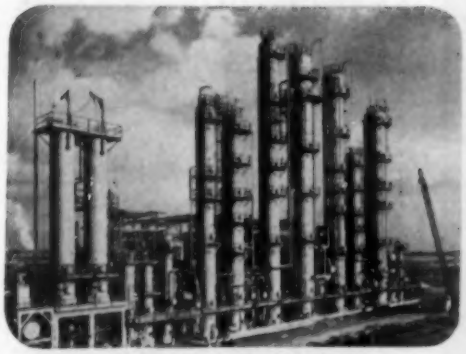

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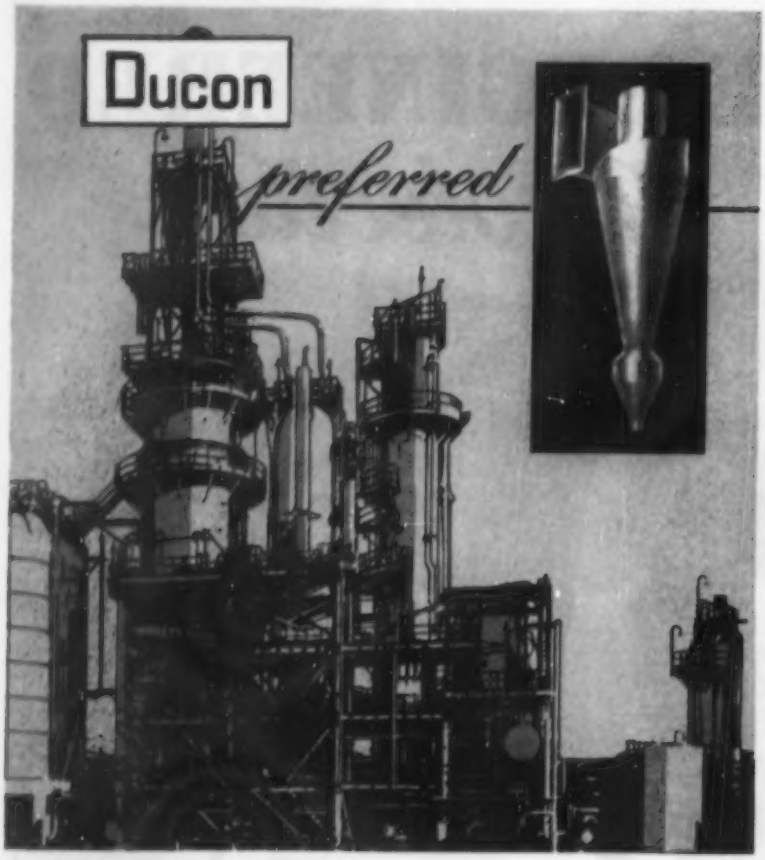

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What's Happening. . .

Technical service division of the Research and Development department.

McPherson and Hankins Reassigned at Pure Plant

In managerial changes at the Heath refinery of Pure Oil Company at Newark,

Hankins

McPherson

Ohio, E. E. McPherson has become management advisor and David P. Hankins manager of the refinery.

McPherson, who has been at the Heath refinery since it started operations almost 35 years ago, was formerly manager. Hankins has been serving as assistant to the manager. Hankins has been in Pure Oil's Refining division for 30 years.

Indiana Standard Building Unit Operation Computer

Operation of an oil refinery unit—even though it is not yet built—will be revealed by proxy by a new electric analog computer in the Standard Oil Company (Indiana) engineering research laboratories at Whiting, Ind.

In addition to being used in designing projected refinery units, the electronic device will make it possible for research engineers to improve control characteristics of existing units and solve general engineering calculations.

Dr. Max G. Paulus, vice president of manufacturing, said the new computer is expected to be put in operation about July 1, 1955.

"When a refinery unit to be built in the future is in design stages of planning, the computer can be used to determine the most efficient location and size of valves, controls, piping, and other parts," he said.

"Thermal stresses in any part of the unit can be determined in advance. The equipment can then be designed more accurately than ever before to fit these needs.

"Unit capacity can also be more accurately determined in advance. The same is true for instrument settings, as well as for establishing the best procedure for starting up or shutting down the unit."

Dr. Paulus pointed out that one of the great advantages of the analog computer is that abnormal conditions can be imposed on it electronically that would never be tried deliberately on an actual unit.

Arab States Told to Form Petroleum Bureau

Recommendations have been made to member governments in the Arab League that they establish a central petroleum bureau to study Arab state oil concessions,

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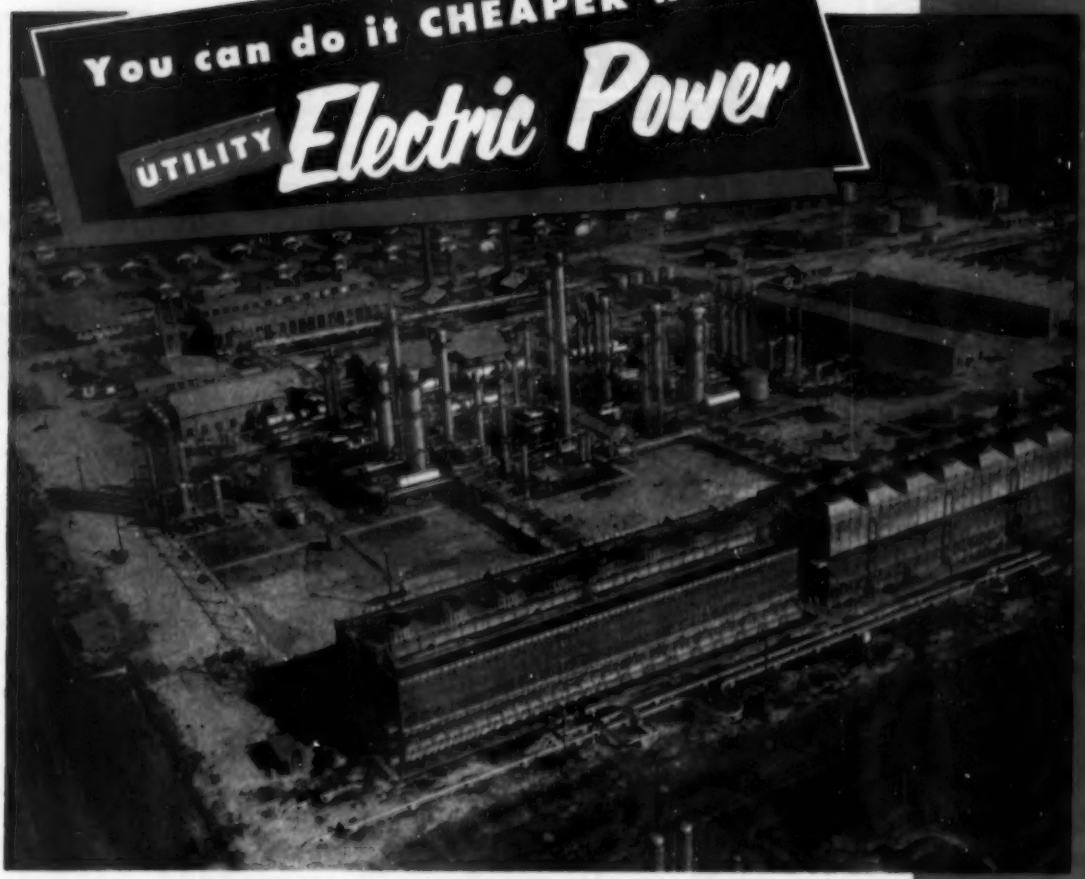

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Oakland 1, Calif. Portland 7, Ore. Washington 6, D. C. San Juan 23, P. R.

What's Happening. . .

compile oil statistics and foster wider use of products from Arab crude in non-producing Arab countries.

The recommendations were made by the Arab League Petroleum Conference, which also suggested the construction of more refineries in the Arab world. It believes, it added, that this would reduce the cost of products in Arab countries while providing more jobs for their nationals.

API Committee Announces Housing Plans for 1955

Because the size of the 35th annual meeting of the American Petroleum Institute, to be held in San Francisco next November, will tax that city's hotel facilities, a special API housing committee has been set up on the West Coast to handle hotel assignments.

The API has announced that all reservation requests must be sent to this special committee. Its address: API Housing Bureau, 61 Grove Street (Room 300), San Francisco 2, Calif.

Under the hotel reservation plans announced by the committee, all requests for accommodations sent to the 61 hotels participating in the meeting plan will be referred automatically to the Housing Bureau.

The San Francisco meeting will bring about a number of changes in the Institute's normal operating plans. Instead of one hotel serving as API headquarters, as is the general practice in Chicago, the assignment will be split among four hotels —the St. Francis, Fairmont, Palace and Mark Hopkins.

General sessions, which usually draw large audiences, will be held in the Curran theater, on Geary Street.

Here's the hotel picture:

Fairmont Hotel—Transportation Division headquarters; all transportation group sessions and committee meetings; public relations group sessions; board of councillors meeting.

St. Francis Hotel—Refining and Marketing Divisions headquarters; all refining group sessions and committee meetings; all marketing meetings, with the exception of the marketing group sessions, which will be held in the Mark Hopkins Hotel; all group sessions of the Lubrication, Statistics and American Petroleum Industries committees.

API Press headquarters will be in the St. Francis.

Palace Hotel: Production Division headquarters; all production group and committee meetings; Financial and Accounting sessions and meetings; Safety and Fire Protection committee meetings.

Mark Hopkins—API board of directors and executive committee meetings; Fundamental Research group sessions and committee meetings.

Registration desks will be located in the Fairmont, St. Francis and Palace Hotels.

The API urges reservation requests be made as soon as possible, listing first, second and third choices. On May 1, hotel assignments will be made by the Housing Committee. Any requests coming in after May 1 will be handled on a first-come-first-served basis, after prior requests have been filled..

Sun Starts Work on Lab

Construction has started on a new $400,000 production research and development laboratory and service building for Sun Oil

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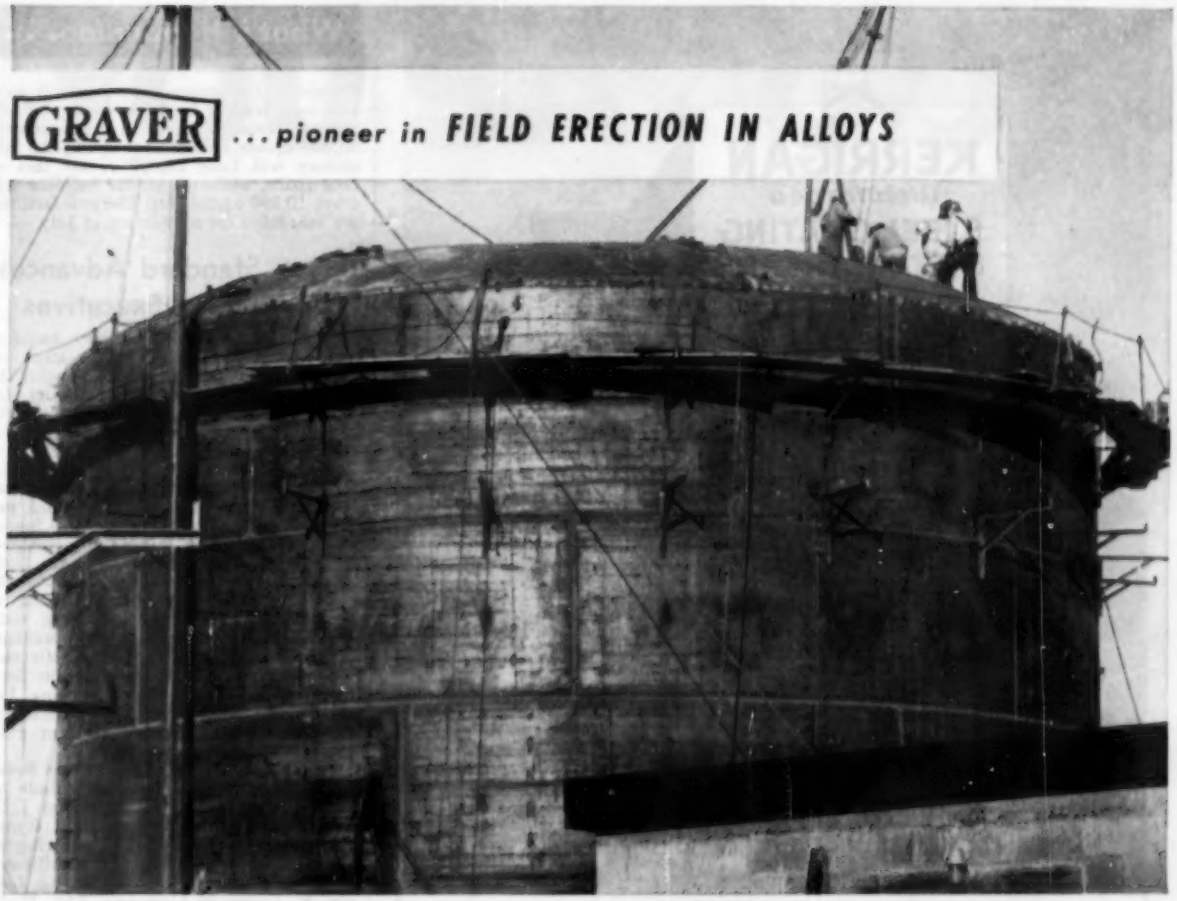

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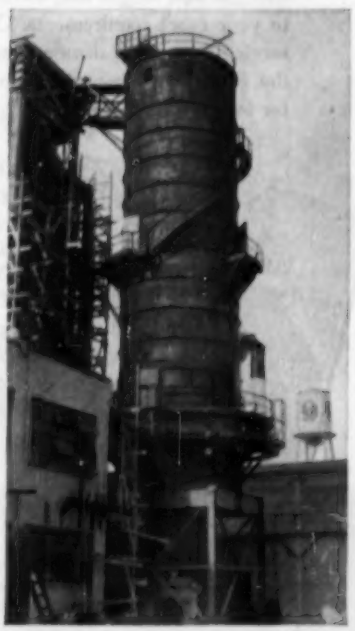
For all industries—chemical, petroleum, food, pharmaceutical—Graver fabricates in nickel, stainless, clads and aluminum, as well as in carbon steels. Precision work, painstaking care, intensive inspection methods—these are integral parts of the Graver method. Taken together, they mark Graver as a source worthy of your consideration.



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What's Happening. . .

Company. The structures, being built on a 14½-acre tract of land just north of Richardson, Texas, will take in approximately 30,000 square feet of floor space; the laboratory will have 20,000 square feet of floor space, while the service building will cover 10,000 square feet. The new facilities are scheduled for completion in July.

Jersey Standard Advances Four Refining Executives

John J. Waybright, refinery engineer and executive, has become assistant refining coordinator in connection with the North American refining activities for Standard Oil Company (New Jersey). His assignment was part of a series of appointments announced by the company.

With his appointment, Waybright transfers to New York from Everett, Mass., where he has served for the past two years as refinery manager for Esso Standard Oil Company, Jersey's principal refining and marketing affiliate in the U. S.

Announced at the same time was the appointment of Paul J. Harrington as general technical advisor covering technical and associated economic problems in the coordination of Jersey refineries. This assignment will transfer him from Standard Oil Development Company, Jersey's research and engineering affiliate, which he has served as assistant chief engineer since 1950.

Additional appointments in the Refining Coordination department include assignments of A. T. Rynalski and J. E. Woodward to area advisory posts. Rynalski will become area advisor covering refining activities of two Caribbean affiliates, Creole Petroleum Corporation and Lago Oil & Transport Company, Ltd. Woodward will become area refining advisor for the United Kingdom, Erie and France, succeeding M. J. Jamieson, who will retire this year.

Scholl Succeeds Walsh As 1955 APIC Chairman

Robert H. Scholl, of Esso Standard Oil Company, has been elected the 1955 chairman of the American Petroleum Industries Committee, succeeding Joseph P. Walsh, of Sinclair Refining Company. William F. Kenney, of Shell Oil Company, has been elected vice chairman to succeed Scholl in that post.

Hillyer B. Brown, of Standard Oil Company of California, and Henry L. O'Brien, of Cities Service Company, have been named members of of the committee. Total membership of the APIC is now 16.

SOD Names Brown to Head Educational Activities

A Scientific Liaison Office has been created by Standard Oil Development Company. The unit, to be managed by Dr. Cecil L. Brown, will coordinate the company's activities with universities, institutes, scientific societies and scientific consultants. Dr. Brown was also appointed chairman of the Contributions and Research Grants Committee.

The company reported that its 1954 grants to educational institutions totaled $400,000. These included grants for specific research of direct interest to the company in its work on chemicals and petro-

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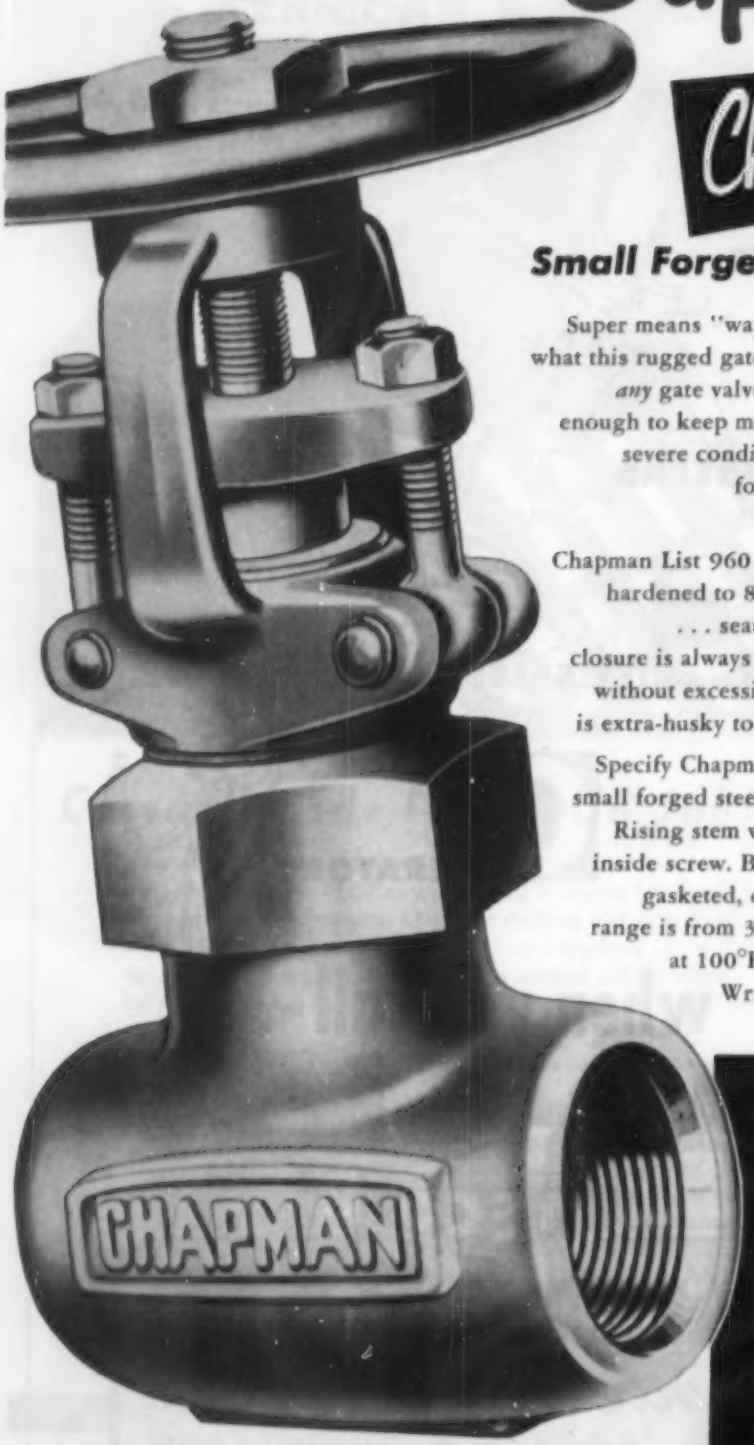

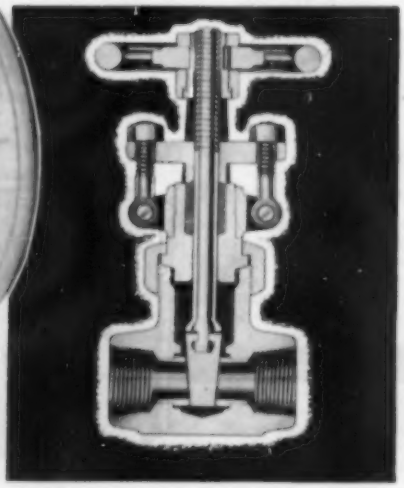

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leum, for fundamental research, for scientific consultants at universities and for use by industry organizations such as the American Petroleum Institute.

Great Northern Oil Adds Three Key Men to Staff

Three key officials have been named to administrative posts at Great Northern Oil Company, St. Paul, Minn., which is constructing a $25 million refinery near Pine Bend on the Mississippi River.

They are John W. McPartland, Tulsa, named chief accountant and assistant treasurer; Robert G. Little, Minneapolis, traffic manager; and Richard L. Morris, Corpus Christi, Texas, purchasing agent and assistant secretary.

McPartland was formerly with Deep Rock Oil Corporation as assistant manager of the Auditing department and staff assistant to the president.

For the past five years Little has been associated with the Minneapolis division of Phillips Petroleum Company as supervisor of the Traffic and Order departments.

Morris has recently been purchasing agent for Great Southern Chemical Corporation.

General Petroleum Raises Rothenberger at Torrance

James T. Rothenberger has been appointed general maintenance superintendent at General Petroleum Corporation's Torrance, Calif., refinery.

Rothenberger joined the company as a roustabout in 1933 and since that time has worked at both the Vernon and Torrance plants for the Engineering department.

Prior to his promotion, he was assistant maintenance superintendent, a post he had held since 1947.

Gray and Connolly Draw New Positions at Gulf Oil

Archie D. Gray has been elected associate general counsel of Gulf Oil Corporation and Russell G. Connolly has been elected secretary.

Gray has been associate general attorney for Gulf and various of its subsidiary companies since 1947. Connolly has been a member of the company's Law department since 1948.

Both Gray and Connolly will continue to be located at Gulf's general office in Pittsburgh.

Los Angeles Smog Plan Would Close Refineries

A plan for alerting the public in event of a smog attack dangerous to health in the Los Angeles area provides for oil refinery shutdowns and halting of automobile traffic under certain conditions.

Los Angeles County Counsel Harold W. Kennedy gave a joint meeting of county supervisors and a 13-man committee of medical and scientific experts these details:

- A network of stations would be set up around the county where continuous analyses of smog would be made.
- When dangerous levels were reported, press and radio would carry orders to

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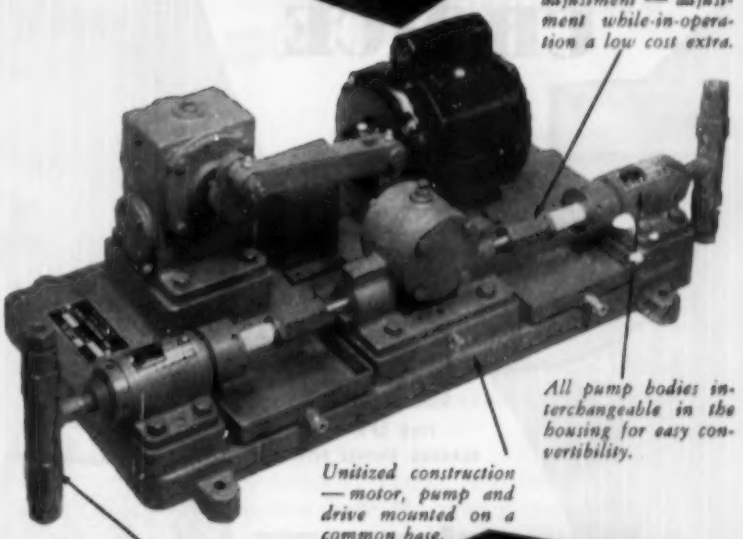
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All pump bodies interchangeable in the housing for easy convertibility.
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Hills-McCanna "U" Type Proportioning pumps combine precision operation with high standards of convenience and versatility not ordinarily associated with pumps of this type. The "U" pump is easy to install and can be converted quickly and economically for changing service requirements.

If you must continuously meter or proportion small volume flows with great accuracy, it will pay you to consider a Hills-McCanna "U" Type Pump. Capacities range from 0.10 to 24 gph per feed, 1, 2, 3 and 4 feed units are available.

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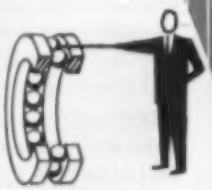
Rig it up and forget it. EMSCO Ball Bearing Swivel Fittings are designed with built-in stamina for the toughest jobs, conservatively rated with an unusually high safety factor. Examine EMSCO Fittings — compare their easy turning quality. Compare the patented method of sealing against leakage. Compare prices. Regardless of the application, order EMSCO for your next job. You'll get years of extra service. TO ORDER: Simply state type of application, pressure, temperature, pipe size and desired ends.



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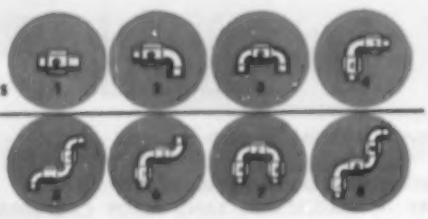

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What's Happening. . .

the public to stop rubbish burning, to cease auto operation and, in event of unusually dangerous concentration, to shut down refineries and other industries.

The committee of experts has as its job the establishment of various danger levels such as "moderate, severe, critical and dangerous."

Tide Water Names Caine To Head Refinery Plans

George C. Caine has been relieved of all his former duties at Tide Water Associated Oil Company in order to direct and coordinate all activities relating to the planning, design and development of the company's new refinery scheduled to be built somewhere along the eastern seaboard. Caine has been serving as general superintendent of the company's Bayonne, N. J., refinery.

Caine

Caine joined Tide Water Associated in 1926 as an engineer in the Development department at Bayonne. He was named assistant general superintendent of the refinery in 1938, and general superintendent in 1943.

Indiana Standard's Burton, Industry Pioneer, Dies

Dr. William M. Burton, retired president of Standard Oil Company (Indiana) and noted Chicago industrial pioneer, died December 29 at Miami, Fla. He was 89 years old.

With associates, Dr. Burton developed the first commercially successful cracking process to make more gasoline out of crude oil, thereby making a large contribution to modern petroleum refining technology. In 1946 he was honored by the American branch of the Newcomen Society of England as a "pioneer in oil cracking."

Dr. Burton joined the Standard Oil Company (Indiana) organization in 1890, soon after receiving a Ph.D degree from Johns Hopkins University. He rose from chemist to general superintendent, to director, to vice president and, in 1918, to president. He resigned the presidency in 1927, continuing in an advisory capacity as a member of the board of directors until 1928.

Shoemaker, Formerly of Jersey Standard, Dies

Harry L. Shoemaker, retired executive of Standard Oil Company (New Jersey), died of a heart attack at East Orange, N. J., December 19. He was 62 years old.

Shoemaker, secretary of Jersey's coordinating committee when he retired, joined what is now Esso Standard Oil Company at its Bayway refinery at Linden, N. J., in 1915. In 1927 he was transferred to Jersey's New York headquarters as assistant manager of the Coordination department.

For more data on advertised products, use Readers' Service Cards, last page.

Cyanamid's Aerocat Triple A* HIGH ALUMINA CATALYST is now available in commercial quantities

The world's first commercially-proved High Alumina Catalyst (25%) offers superior activity stability, lower stack losses and excellent selectivity . . .

Cyanamid is pleased to announce that production facilities to manufacture AEROCAT TRIPLE A High Alumina Catalyst in commercial quantities have been completed. We are pleased, also, with the immediate and growing acceptance this important new catalyst has received from the refining industry.

AEROCAT TRIPLE A has an alumina content of 25% by weight. Laboratory research indicated this higher amount of alumina could be incorporated into fluid catalyst by special techniques so as to offer several important advantages over regular 13% alumina catalysts. These indications were fully proved by more than a year's successful trial performance in a commercial fluid unit at a major oil refinery. These advantages include:

Superior Activity Stability – AEROCAT TRIPLE A showed a consistent equilibrium activity 15-25% higher than 13% alumina catalyst. This means higher cracking efficiencies.

Lower Stack Loss – AEROCAT TRIPLE A gave a considerable reduction in the quantity of catalyst lost from the regenerator stack. For most operations, a reduction of 20% or more can be expected. This feature provides more effective retention of fresh catalyst additions and gives flexibility to withdraw and discard inactive or contaminated catalyst.

Excellent Selectivity – AEROCAT TRIPLE A gave product distribution equal to that of 13% alumina catalyst. With some feed stocks, tests have shown *improved* selectivity with Triple A.

By using AEROCAT TRIPLE A High Alumina Catalyst, you now have the money-saving choice of: (1) increasing output volume per ton of catalyst; or (2) improving performance at the same catalyst usage rate. Both mean lower catalyst cost to you.

Contact your Cyanamid representative for full details on this important new catalyst development.

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High Alumina Catalyst
AMERICAN Cyanamid COMPANY
Refinery Chemicals Department
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Who's Meeting . . .

AIChE at New York . . .

. . . **X-rays** are now being used to make studies of fluidization. By means of an X-ray source and an X-ray detector, combined in a unit that can be moved up or down over the entire height of a laboratory scale fluidization column, it is possible to measure irregularities within the powder-gas mixture, much in the way that X-rays have long been used to detect nonuniformities or defects within metal castings, which the eye cannot detect (E. W. Grohse, General Electric Research Laboratory).

. . . **Recent** studies on phenol extraction of lubricating oils may have application to other extraction processes. Principal findings of this recent work were: Extraction temperature has a very marked influence on stage efficiency; higher temperatures give higher efficiencies by reducing all phase viscosity. Interfacial tension, though not a major variable in lube extraction, also has a major effect on stage efficiency by affecting drop size. Interstage entrainment in either one or both phases reduces efficiency markedly, entrainment in the extract being most serious. Flow capacity of extractor towers used in lube service increases with increasing extraction temperature. Viscosity of the continuous phase in the vicinity of the feed stage appears to be the governing factor (J. R. Felix and C. H. Holder, Standard Oil Development Company, Linden, N. J.).

. . . **Acetylene** may be recovered from dilute mixtures by fractionation in a moving bed of adsorber according to recent pilot plant studies using activated carbon as the adsorbent. Practical application of these results may be made to the design of apparatus for concentration of acetylene produced from natural gas or partial oxidation and thermal cracking (J. Happel, W. H. Kapfer and M. Malow, New York University).

. . . **Austenitic** stainless steel is the most suitable material for use with hydrogen and high pressures according to Yale University investigators. They say the effects of hydrogen on the mechanical processes of selected steels and special alloys with pressures up to 4000 atmospheres and temperatures up to 500 C. They distinguish between two types of hydrogen attack—embrittlement at low temperature and chemical attack at high temperature. Hydrogen embrittlement, according to the authors' definition, is the decrease in ductility of metal which occurs without the formation of visible cracks or change in microstructure or composition. While this embrittlement can occur at any temperature it is often masked at high temperature by the effects of chemical attack. In chemical attack, the hydrogen reacts with carbon in steel to form methane; the destructive effects of this action results from both decarburization and internal pressures built up by the methane formed. The investigators warned that high temperatures are not required for hydrogen damage, and that many materials may be dangerously embrittled at even room temperatures by hydrogen at 2000 atmosphere pressure (H. C. Van Ness and B. F. Dodge, Yale University).

. . . **Ammonia** has unique properties as a selective solvent for separating hydrocarbon mixtures according to molecular type. To enhance ammonia's dissolving power, methylamine was found suitable; where its dissolving power was too high, water made an effective solubility-releasing agent. These agents were used to adjust solubility so that the amount of hydrocarbon in solution in the solvent lay between 10 and 30 percent. Using a 20 stage counter current static extractor the Penn State investigators studied ammonia extraction of cracked naphthas, separation of benzene from straight run and cracked naphthas, olefin-saturate separations and extraction of fractional stocks and lubricating oils (M. R. Fenske, H. Lawroskin, R. G. Geier, Pennsylvania State University).

. . . **A new** efficient type of counter current extraction apparatus—a rotating disc contactor—was described by Shell engineers. Efficiency of a commercial installation—extraction of lubricating oils with furfural—was shown to be about six times that of a packed tower. Another commercial use is in the separation of mixed chlorinated hydrocarbons. The device consists of a number of compartments formed by installation of stator rings in a tower with a rotating disc centered in each compartment and supported by a rotating shaft. Varying the rotor speed provides flexibility to maintain high efficiency over a wide range of feed and solvent rates, speed properties and product specifications. Other applications of the device which have been studied include the extraction of mercaptans from gasoline fractions and the purification of synthetic detergents. A commercial installation in gasoline service is anticipated in the near future (G. H. Reman, Koninklijke Shell Laboratorium, Amsterdam, and R. B. Olney, Shell Development Company, Emeryville).

. . . **Fluid** Char Adsorption is a new separation process that may be adapted for the separation of petrochemical streams from refinery residue and natural gas, the purification of hydrogen and the concentration of acetylene from light hydrocarbon combustion and cracking process. Design advantages for the process: a small adsorbent inventory, high heat transfer coefficients, high allowable vapor and solids velocities (minimizing the volume), adaptability to stage wise cooling (minimizing char circulation rate, exchange surfaces and utilities), direct char heating with combustion gas and reactivation operations (minimizing high temperature equipment problems); and direct and simple solids flow control. Economic studies on the new process for several refinery applications show that it is able to compete with the best conventional processes. Continuous countercurrent selective adsorption of hydrocarbons over a finely divided fluidized activated carbon is the heart of the new process. The power plant unit was designed to recover C_2 and C_3 hydrocarbons from refinery residue gas streams (L. B. Etherington, H. W. Scheeline, R. J. Fritz and E. W. Nicholson, Standard Oil Development Company).

. . . **Increased** emphasis should be placed on in-plant reduction of pollutional waste, the first step in a waste abatement program. Maximum possible elimination of waste at its point of origin in the chemical plant is a primary function of the chemical engineer responsible for production operations, contrasted with other phases of pollution abatement which be-

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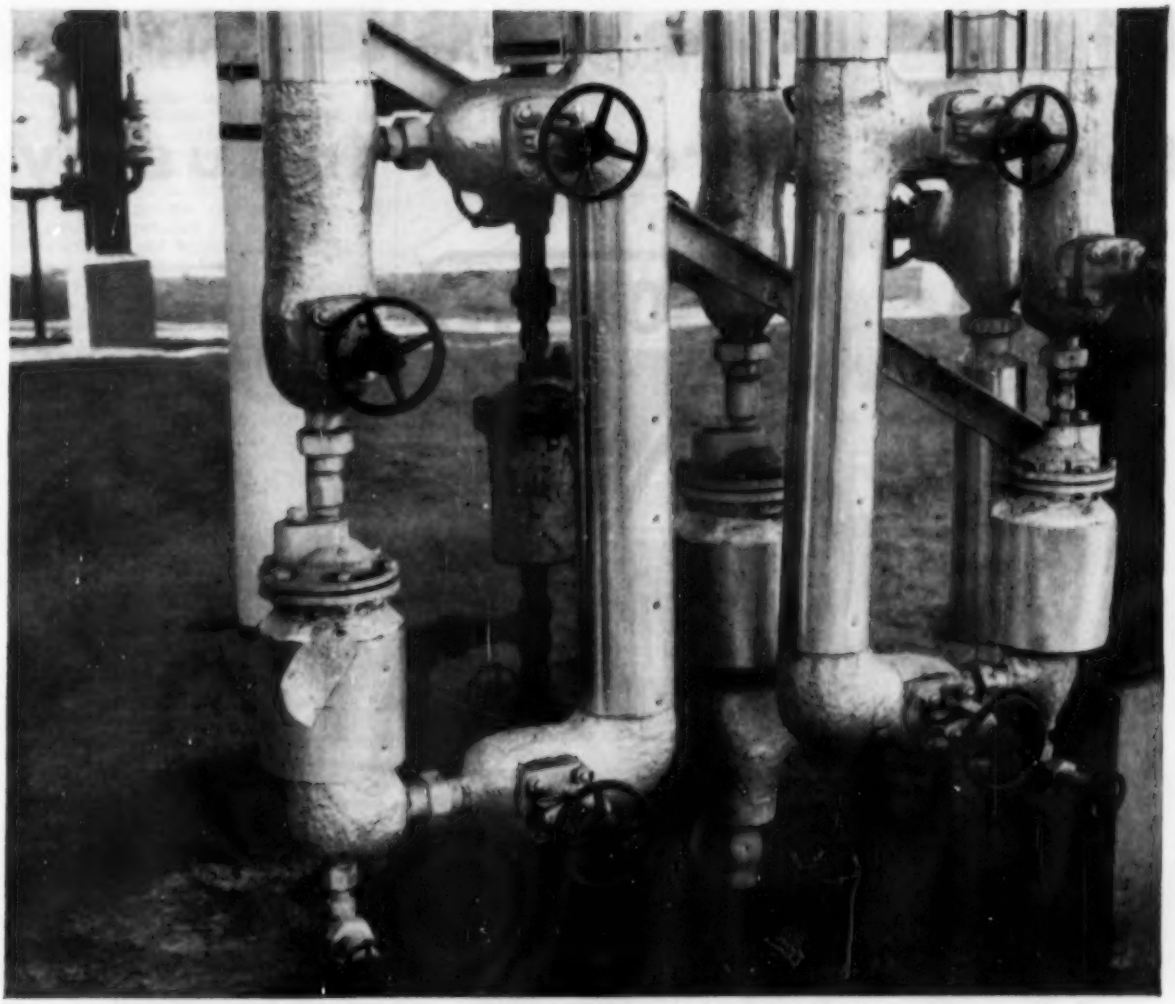

Picture of Low Cost Steam Trapping . . .

The Armstrong steam traps pictured above are in a field processing plant in Oklahoma. It's a nice installation—traps neatly installed in bypasses, lines well insulated, blowdown valve below each trap. Obviously, no corners have been cut to save nickels. Then, what do we mean by "picture of *low cost* steam trapping." Simply this:

Low cost traps—the price tag doesn't read any lower, but, because of high capacity, you can usually select an Armstrong trap one size smaller than other makes.

Low cost installation — Armstrong offers a choice of either side inlet-side outlet or bottom inlet-top outlet traps in most sizes so that hook-ups can be made with a minimum of labor and fittings. All traps can be equipped with internal check valves, and the three smallest traps are available in integral strainer style. These optional built-in features mean lower installation costs.

Low cost maintenance—Armstrong traps last for long periods without repairs because the valves and seats are corrosion-resistant, file-hard chrome steel, ground and then lapped together; and all other working parts are corrosion-resistant stainless steel. Materials and workmanship are unconditionally guaranteed.

Low production costs—because Armstrong traps provide fast drainage and have large air handling capacity, they provide maximum output from steam heated units and give a bigger return on equipment investment. They save steam, too, through reduction of non-productive radiation losses and freedom from leakage.

For *low cost* trapping it pays to specify "traps shall be Armstrong."

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ARMSTRONG STEAM TRAPS

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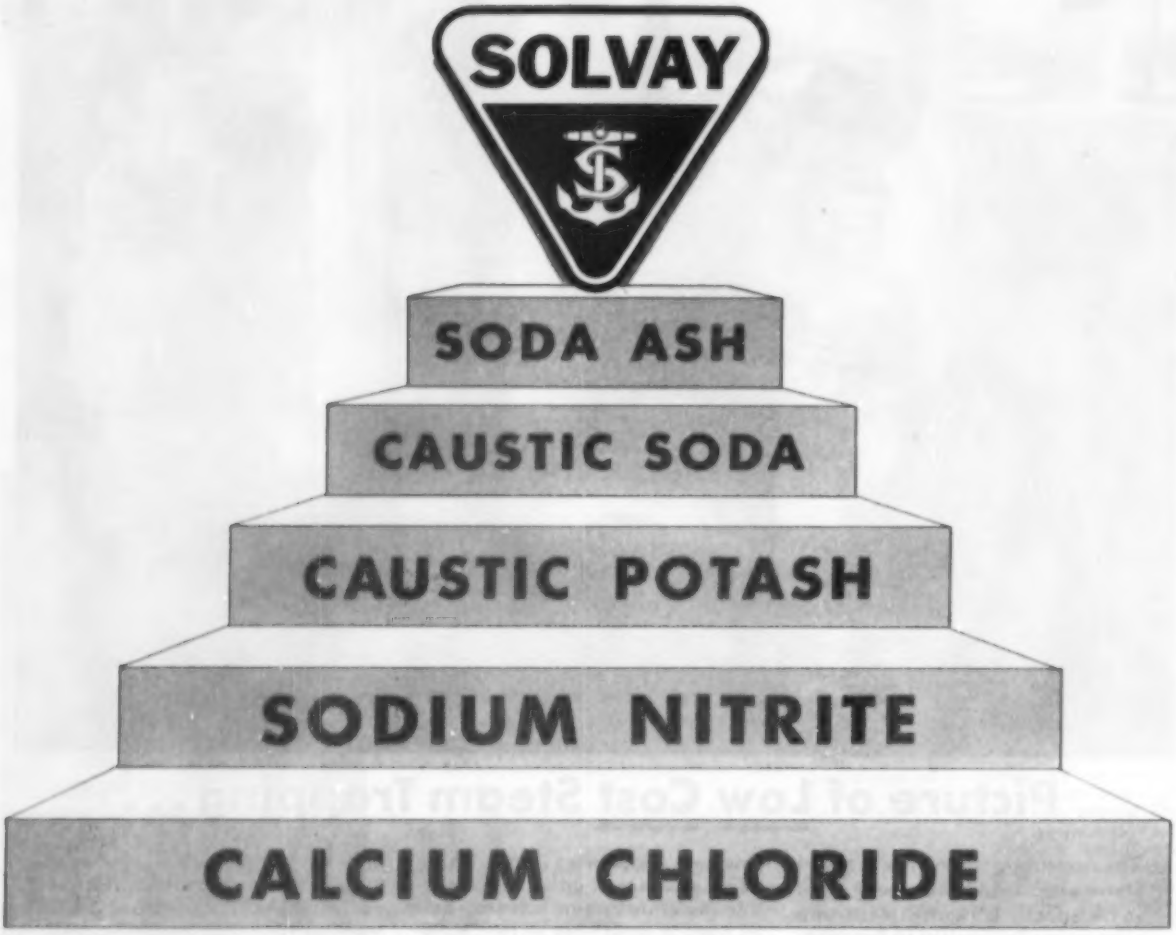

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long largely to the sanitary engineer or the aquatic biologist. Reduction at the source is said to be far less costly than waste treatment operations and, in some notable cases, can even be profitable. Several methods for in-plant pollution reduction include process changes, salvage of materials, by-product recovery, better housekeeping and waste collection (C. F. Gurnham, Michigan State College).

. . . **Use of** polyethylene in construction of a perforated plate extraction column is desirable in extraction operations in which the organic phase is continuous and the aqueous phase is dispersed. Most perforated plate columns work better under the opposite condition—organic phase dispersed—because the water phase preferentially wets steel plates. British workers overcame this obstacle by using polyethylene plates which were preferentially wetted by the organic phase (F. H. Garner, S. R. M. Ellis and J. W. Hill, University of Birmingham, England).

ACS At Fort Worth . . .

. . . **A completely** automatic sulfur determination has been developed based on converting the sulfur in the sample to sulfur dioxide which is estimated iodimetrically. The use of this device in an analytical inspection laboratory has doubled the daily output per analyst. The automatic procedure is more precise than manual operations (L. M. Adison and M. O. Geinand, Esso Laboratories).

. . . **Two types** of petroleum products which prove to be troublesome during sulfur determination are the highly volatile liquid samples and the heavy distillates. A refrigerated lamp has been designed to handle the former materials and a novel wick tube heater and flame-propagating tip have adequately solved the combustion of the heavier distillates. The effective range of this apparatus has thus been extended to include distillates up through medium gas oils (C. Howard Hopkins, Skelly Oil Company).

. . . **In many** chemical processes the knowledge of the oxygen content in streams and vessels is necessary. Although laboratory methods of adequate accuracy for determination of trace amounts of oxygen in gases do exist, the changing characteristics of plant processes demand a continuous measurement. One of these laboratory methods has been adapted to a continuous oxygen analyser of the colorimetric-differential, photometric type suitable for plant service. The instrument may be used to monitor trace amounts lost in any gas which does not readily destroy the oxygen sensitive reagent, sodium anthroquinone beta-sulfonate. The analyser has shown excellent stability in plant service. Long time accuracy is about plus or minus 5 percent. The sensitivity can be adjusted to any range between zero to 50 and zero to 500 ppm oxygen (S. W. Karasek, R. J. Loyd, D. E. Lupfer, and E. A. Houser, Phillips Petroleum Company).

. . . **A petrochemical** waste which contained many compounds such as alcohol, aldehydes, glycols, organic acids, etc., was tested for biological oxidation. Of some 20 compounds tested, the primary and secondary alcohols and the aldehydes appeared to be the easiest to oxidize. Tertiary butylalcohol, methylal, and glycols were quite resistant to biological oxida-

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...TRY LAGONDA

The famous Lagonda 1100 Series refinery motor, with Type UO cutter head. A widely used combination.

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Here's a book prepared on the basis of over 50 years' experience. It has many valuable tips on tube cleaning procedure, and lists cutter heads and motors with data on their capabilities and usage. Covers other equipment too, such as catalyst cleaners, foot valves, hose, couplings, cleaners for large pipes and very small tubes. Write for illustrated Bulletin Y-34.

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When clean-outs drag, 'phone your Lagonda man, or write Elliott Company, Springfield, Ohio. To get your stills back on stream *quick*, try Lagonda.

ELLIOTT Company

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STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOSUPERCHARGERS • TUBE CLEANERS • STRAINERS

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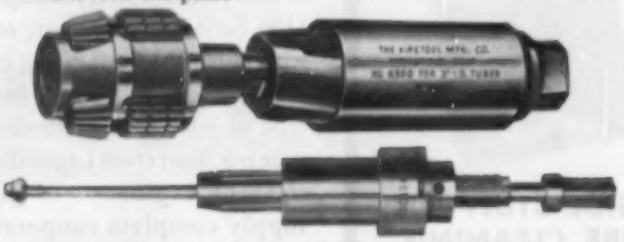
Convincing proof of the rapid and efficient tube maintenance done by Airetool equipment can only be *fully shown* on the job!

We could talk forever . . . about the complete line of cutter, drill and brush cleaner heads to fit every size of straight and curved tubes . . . or the powerful, high-speed motors that provide extra-husky driving torque, and "load down" to low R.P.M. without stalling! We could tell you about Airetool's precise slip-fit ground construction that permits easy disassembly and reassembly without special tools . . . or any of the thousand and one reasons why we know that Airetool Tube Maintenance Equipment is foremost in its field!

Words alone convey but half the picture . . . we'd rather show than tell you—so ask your nearest Airetool representative for a demonstration . . . just name the time and the place!



Just one of the many efficient AIRETOOL combinations for rapid, economical, thorough tube maintenance . . . the series "6000" ball bearing motor, shown here with a single-expansion type cutter head, and the G-800 ball bearing thrust quick-rolling expander.

WRITE TODAY to The Airetool Manufacturing Co., 328 S. Center St., Springfield, Ohio—get full information about the complete line of Airetool Tube Maintenance Equipment for your specific industrial needs.

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Remember . . . there's an AIRETOOL Tube Cleaner and Tube Expander for Every Type of Tubular Construction.

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BRANCH OFFICES: New York, Philadelphia, Chicago, Tulsa, Houston, Baton Rouge.

Who's Meeting . . .

tion. The degree of acclimation of the bacterial sludge seemed to have an important bearing on the rate of oxidation. Separate runs with the same compound using different acclimated sludges gave varying rates of oxidation (Richard Hatfield, Southwest Research Institute).

. . . **A mechanism** has been developed which will control the flow rate of granular solids in the range of 1 to 10 thousand per hour with an accuracy of about 2 percent. The mechanism is a miniature lock-hopper which consists of two separate pistons on a vertical shaft, the upper piston being slightly smaller in diameter than the lower one. The piston is designed to maintain a continuous seal and fit in cylindrical chambers which form succeeding sections of the mechanism. The solids flow control device is located at the bottom of the standpipe hopper. As the pistons move upward the lower piston forms a seal and the upper piston disengages its cylinder, thereby permitting solvents to fill the small lock-hopper. On the downward stroke the upper piston forms a seal before the lower piston disengages to discharge the hopper. The volume increases as the piston moves downward and the solids fall away from the upper piston and bearing surfaces, thereby preventing excessive wear of the mechanism. The mechanism has been used successfully with rather coarse particles employed in the Fluid Coking process and to a limited extent with fluid cracking catalysts (W. J. Metrailer and E. D. Stokes, Esso Standard Oil Company).

In the Future . . .

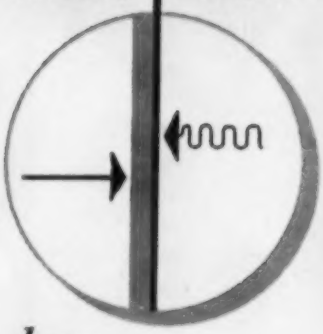
. . . **CMRA** will join forces with CCDA in a technical meeting devoted to chemicals in food and feeds (Chicago, January 20-21) . . . **ASTM**-sponsored Third Annual Conference on Mass Spectrometry will include papers on all aspects of the theory and application of mass spectrometry (San Francisco, May 23-27) . . . **Symposia** at the Conference on Biological Waste Treatment include mechanisms of biological treatment, theory and design of aeration systems, and plant design (Manhattan College, April 13-15) . . . **The annual** symposium on Instrumentation for the Process Industries will include round-table sessions on several interesting instrument problems (College Station, Texas, January 26-28) . . . **AIChE** national meeting plans symposia on nucleation processes, flow of fluids through porous media, extractive and azeotropic distillation, chemical engineering curricula, and differences in chemical engineering theory (Houston, May 1-4) . . . **A symposium** on hydrocarbon chemistry has been planned by Southeastern Texas Section of ACS (Houston, January 27-28) . . . **The Oklahoma** Chapter of NACE is offering its Corrosion Control Short Course again this year (Norman, April 5-7) . . . **The University** of Toronto is also cooperating with NACE to give a short course in corrosion (Toronto, February 2-4) . . . **At its** annual meeting, NACE's technical committee will report on corrosion problems resulting from the use of sulfuric and nitric acids and chlorine . . . **AIEE** in its winter meeting plans technical papers on modernization of the electrical distribution system in a refinery and lighting a modern refinery process unit (January 31-February 4, New York) . . . **The New York** chapter of ISA is scheduling a conference on instrumentation for data reduction and presentation (New York, February 23).

CALENDAR OF MEETINGS

JAN. 1955	
10–14	SAE Golden Anniversary (Annual Meeting), Sheraton-Cadillac and Statler Hotels, Detroit.
19–21	Southwestern Gas Measurement Short Course, University of Oklahoma, Norman, Okla.
20–21	Chemical Market Research Association (Joint Meeting with Commercial Development Association), Edgewater Beach Hotel, Chicago.
26–28	Symposium on Instrumentation for the Process Industries, Agricultural and Mechanical College of Texas, College Station, Texas.
27–28	Symposium on Hydrocarbon Chemistry, Sponsored by Southeastern Texas Section, American Chemical Society, Rice Hotel, Houston.
31–Feb. 4	American Institute of Electrical Engineers (Winter General Meeting), Hotel Statler, New York.
FEB.	
13–18	ASTM Committee D-2 on Petroleum Products and Lubricants, Rice Hotel, Houston.
16–17	American Petroleum Institute (Division of Marketing, Lubricating Committee), Sheraton-Cadillac Hotel, Detroit.
25	Natural Gasoline Association of America (Regional Meeting), Scharbauer Hotel, Midland, Texas.
MAR.	
7–11	National Association of Corrosion Engineers, (Annual Conference and Exhibition), Palmer House, Chicago.
20–23	American Institute of Chemical Engineers, Kentucky Hotel, Louisville, Ky.
24–28	American Gas Association (Gas Supply, Transmission and Storage Conference), Wm. Penn Hotel, Pittsburgh.
28–April 1	American Society for Metals (Ninth Western Exposition and Congress), Pan American Auditorium, Los Angeles.
30–April 1	American Power Conference, Sherman Hotel, Chicago.
APRIL	
4– 8	American Petroleum Institute (Safety and Fire Protection Committees, Midyear Meeting), Jung Hotel, New Orleans, La.
5– 7	Corrosion Control Short Course, Sponsored Jointly by University of Oklahoma and the Central Oklahoma Chapter of NACE), University of Oklahoma, Norman, Okla.
13–15	Conference on Biological Waste Treatment, Manhattan College, New York.
13–15	National Petroleum Association (52 Semi-Annual Meeting), Cleveland Hotel, Cleveland.
13–15	Natural Gasoline Association of America (Annual Convention), Baker and Adolphus Hotels, Dallas, Texas.
13–15	American Society of Lubrication Engineers (Annual Meeting and Lubrication Exhibit), Hotel Sherman, Chicago.
18–19	Third National Air Pollution Symposium, Pasadena, Calif.
18–20	American Society of Mechanical Engineers (Spring Meeting), Lord Baltimore Hotel, Baltimore, Md.
MAY	
1– 4	American Institute of Chemical Engineers, Shamrock Hotel, Houston.
1– 4	Liquefied Petroleum Gas Association (Annual Convention), Conrad Hilton Hotel, Chicago.
9–12	American Petroleum Institute (Division of Refining, Midyear Meeting), Jefferson Hotel, St. Louis, Mo.
16–18	American Petroleum Institute (Division of Marketing, Lubrication Committee), The Greenbrier, White Sulphur Springs, W. Va.
18	Chemical Market Research Association (Annual Business Meeting), Hotel Plaza, New York.
JUNE	
6–15	Fourth World Petroleum Congress, Rome, Italy.
12–17	Society of Automotive Engineers Golden Anniversary Summer Meeting, Chalfonte Haddon Hall, Atlantic City, N.J.

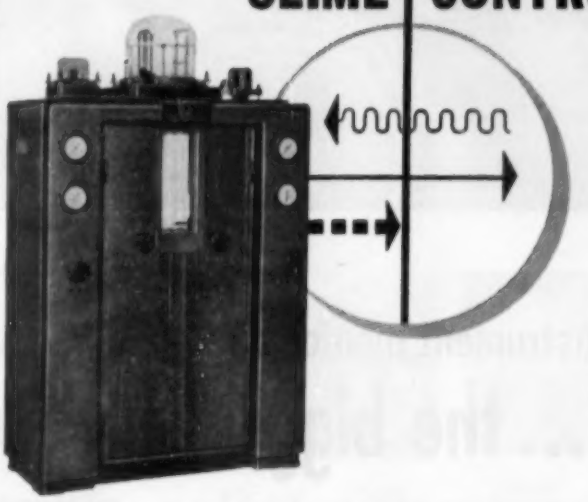
Where you need

HEAT | EXCHANGE



Be sure you have

SLIME | CONTROL



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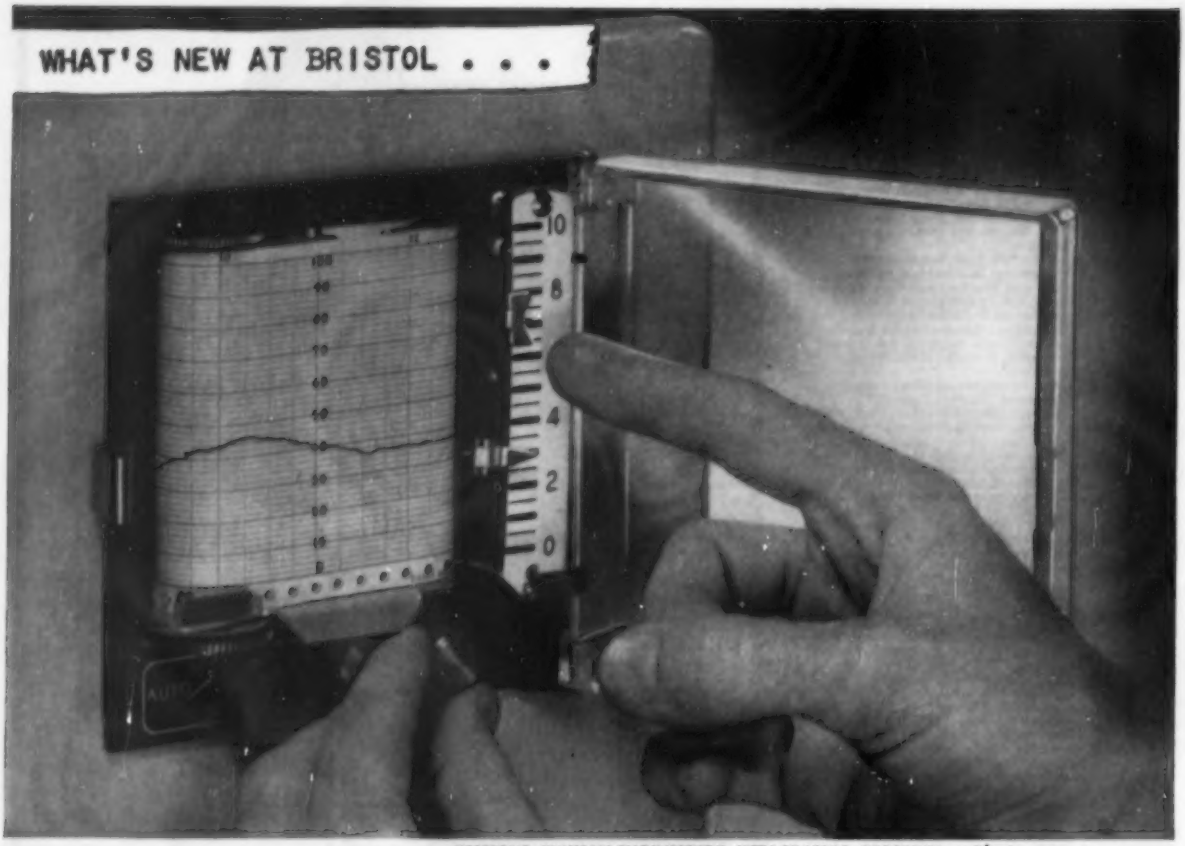

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What Suppliers Are Doing . . .

Schwab Scott Tragard Moses Burgan Rice Calkins Brekelbaum Coleman

Gustav Schwab, Jr., assistant purchasing agent for **Dravo Corporation** since 1951, has been appointed manager of the firms' Marietta, Ohio, pipe fabrication plant.

Richard M. Scott has been appointed sales representative for **Wolverine Tube**, Division of Calumet & Hecla, Inc. He will make his headquarters in the company's general sales office in Detroit and call on Wolverine's wholesale accounts only in Wayne County, Mich.

John O. Tragard has been appointed sales manager of **Mason-Neilan Regulator Company, Ltd., of Canada.** He has been connected with the industrial control equipment field for many years and previously served in sales executive capacities with The Foxboro Company and Hammel-Dahl Company.

Richard Moses, formerly general manager of Process Instruments and Equipment Company, Charleston, W.Va., has become sales and service representative for **Western Supply Company**, Tulsa, for the West Virginia area.

Dean Burgan has joined the technical staff of **Electric Steel Foundry Company.** He will work in parallel with other supervisors in the company's Metallurgical department. For the last 12 years he has been on the staff of Battelle Memorial Institute.

Dr. William H. Rice has also joined the technical staff of Electric Steel Foundry Company. He will work on cast weldment design and cast fabrications. For the past two years Dr. Rice has been on leave of absence from Oklahoma A. & M. College for the purpose of working for his doctorate at Oregon State College.

L. O. Calkins, Colorado district sales manager for **The Fluor Corporation, Ltd.**, has been named to head a new Fluor district sales office in Denver. Calkins was formerly manager of project coordination at Fluor's home offices in Los Angeles. William Bowles, formerly with Fluor's Houston district sales office, will be transferred to Denver to serve as district sales engineer.

E. C. Brekelbaum has been appointed assistant to the general manager of **The Thew Shovel Company.** He will, in his new assignment, assume administrative status and have general authority on matters pertaining to methods, engineering and quality control, covering the company's line of power shovels and cranes. Brekelbaum has been with Thew since 1952.

Henry J. Coleman, chief of site development in the Marketing department at **The Standard Oil Company (Ohio)**, has been appointed sales manager of Sohio's Petrochemical department at Lima, Ohio. **Harry S. Knobel**, who has been with Sohio since 1950 in the Marketing Research, will succeed Coleman as chief of site development in the Marketing department.

Schwanhausser Ramsey Jamison Sievert Gwynne Twyman Offutt Frost

Edwin J. Schwanhausser, executive vice president and member of the board of directors of **Worthington Corporation**, has become president as a result of changes made in the company management.

Hobart C. Ramsey, who has been serving as president of Worthington, will become chairman of the board under the changes, succeeding Howard Bruce, who has been elected chairman of the executive committee. Ramsey will continue as chief executive officer. Clarence E. Searle is retiring as vice chairman of the board but will continue as a director. Bruce has been a director of Worthington since 1921 and chairman of the board since 1929.

S. J. (Jim) Jamison, Jr., has been named manager of the new branch office which **Southern Engine & Pump Company** has opened at Beaumont, Texas. Jamison, an engineering graduate from the University of Texas, recently finished specialized training at Southern Engine & Pump's Houston headquarters.

O. M. Sievert, assistant district manager of the Kansas City office of **Elliott Company**, has been appointed Kansas City district manager.

Robert M. Gwynne, who has served **B-I-F Industries, Inc.**, as serviceman, repair parts manager, assistant service manager and exhibit manager, has been named sales engineer for the Los Angeles office of B-I-F Pacific.

W. G. Twyman, formerly manager of A. P. Green Fire Brick Company of Michigan, has been named to succeed J. J. Offutt as general manager of **A. P. Green Fire Brick Company, Ltd.**, of Toronto, Canada.

James J. Offutt, of A. P. Green, has been appointed manager of Domestic and Canadian affiliated companies of **A. P. Green Fire Brick Company** of Mexico, Mo.

E. Vernon Frost will engage in the engineering and sales of all **Pipeline Coating and Engineering Company** products as a result of the recent appointment of Frost Engineering Company as distributor for the former firm in southern California, Arizona, New Mexico and southern Nevada.

Gulf Supply Advances Two to Vice Presidents

T. Deal Reese and George J. Trageser have been named vice presidents of Gulf Supply Company. Reese becomes vice president and regional sales manager, with headquarters in Houston, while Trageser serves as vice president and merchandising manager, with headquarters at the company's home office at Beaumont, Texas.

Reese joined Gulf Supply in 1947, and has recently been serving as Houston district sales manager. Trageser has been with Gulf Supply since its organization in 1947, serving as merchandising manager and a member of the board of directors.

Alco Names Information Head

Dana T. Hughes has been appointed director of information at American Locomotive Company. He has been acting head of the company's new bureau since Novem-

CATALYST CONTAMINATION CURED BY REMOVING ENTRAINMENT IN DISTILLATION UNIT

Equipment Costing $15,000 Pays Out In Under A Week For Large Southwestern Refinery

It was not a difficult problem to trace the cause of mounting catalyst losses to a cat unit feed so poor in color that it was essentially black. Entrainment of liquid from the bottom of the still column could be the only answer.

Here was a situation where a Metex Mist Eliminator would remove the entrainment—but what else might happen? Would this knitted wire mesh separator cause excessive pressure drop? How quickly would it become plugged by coke deposits and make the column inoperable?

Calculations by one engineer showed that the total cost of installing a 25-ft diameter Mist Eliminator, including designing and erecting supports within the still, was approximately $15,000—less than a week's catalyst loss. After considerable study the decision was made, and the Mist Eliminator installed during the next routine turnaround.

When the first run of cat unit feed came from the remodeled crude distillation unit, it was crystal clear and water white. Throughout the normal run no differential pressure across the screen was found.

The problem was solved. Catalyst losses dropped sharply. And the Mist Eliminator has paid for itself in a matter of days.

Have you really analyzed your entrainment costs, and checked the savings a Mist Eliminator could make for you? Perhaps you are losing valuable end products in the exhaust stream. Perhaps you have a nuisance contamination problem. Perhaps the entrainment created in one vessel is causing trouble in a subsequent operation. For entrainment is an inevitable result of most processing and refining operations.

Metex Mist Eliminators perform just one function—and they are doing it in more and more refining vessels every day. They remove liquid entrainment—efficiently and economically—wherever it may occur.

Why not write today for more information on Metex Mist Eliminators. Or better yet, send data on your particular entrainment problem. We'll be glad to have our engineers check this, and send you our recommendations and suggestions. Metal Textile Corporation, Roselle, New Jersey.—(Adv.)

Suppliers . . .

ber, 1953. He was previously employed as assistant to the public and personnel relations manager of Dixie Cup Company, Easton, Pa. He joined Alco in 1952.

Pritchard Holds Open House—

Business leaders of Kansas City, Mo., and out-of-town guests attended an open house last month at this new, modern office structure of J. F. Pritchard & Company at 4625 Roanoke. Constructed of reinforced concrete, faced with ledge stone and brick to conform with surroundings, the building incorporates approximately 46,000 square feet of floor space, including basement. It contains executive offices, a large drafting room, a conference room, library and private offices.

Carbide and Carbon Announces Several Organization Changes

Organizational changes have been announced by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation.

Dr. R. L. Bateman, former manager, Fine Chemicals division, has been appointed to a newly created position as director of product development. In this new capacity, Dr. Bateman will work with John A. Field, who was recently made vice president in charge of sales development and related activities.

W. A. Woodcock has been appointed manager, Fine Chemicals division, succeeding Dr. Bateman. Dr. R. H. Wellman has been appointed manager, Agricultural Chemicals division. Woodcock and Dr. Wellman will assist Dr. Bateman in developing markets for Carbide's newer products.

In another change, H. E. Klein was appointed district manager of the Kansas City district. He had been an assistant district manager in Kansas City.

Babcock & Wilcox Purchases Assets of Globe Steel Tubes

The assets and business of Globe Steel Tubes Company of Milwaukee have been purchased by The Babcock & Wilcox Company.

Under terms of the transaction as approved by the boards of directors of both companies, stockholders of Globe Steel Tubes will get cash for their holdings. A joint announcement made by the companies revealed the selling price was approximately $9,300,000.

Babcock & Wilcox announced that it will continue to operate the Milwaukee plant as part of its Tubular Products division.

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Major Refinery Reports:

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G-E Display Attracts—

The cutaway display of General Electric Company's Small Turbine and Supercharger department's 25-inch DP Turbine attracted much attention at the Iron and Steel Engineers Convention held recently in Cleveland. Shown above is L. W. Gilmartin, supervisor, Advertising and Sales Promotion, pointing out the numerous turbine features. The display is an actual turbine, cut away to show the features.

Appointments Announced in National Distillers Change

Three appointments have been announced by National Distillers Products Corporation in conjunction with the integration of all its chemical activities into one division.

Lee A. Keane, vice president of U. S. Industrial Chemicals Company, Division of National Distillers Products, has been named director of chemical sales, and will be in charge of the sales of all the corporation's chemical products.

Robert H. Cornwell has been appointed director of production, and will be responsible for the production activities of all the chemical plants of the corporation and its subsidiaries.

Dr. Stuart Schott has been named director of research, and will be in charge of the research division which will conduct research and pilot plant operations for the entire corporation and its subsidiaries.

Cornwell, prior to his appointment, served as a vice president and member of the board of directors of Hydrocarbon Research, Inc. Dr. Schott has been assistant research director at National Distillers Products since 1950.

Kaiser Steel Appoints Riggs Assistant Head of Planning

Wilfred R. Riggs, Jr., has become assistant director of general planning at Kaiser Steel Corporation. At the same time, Robert H. Howard was made supervisor, general planning, reporting to Riggs.

Riggs joined Kaiser Steel in 1949 and has since served as research analyst, supervisor, cost section, and as supervisor, market research. Howard has been serving as research analyst and as supervisor of the cost section, general planning.

Laclede-Christy Appoints Chief Industrial Engineer

Clinton B. Fleming has been appointed chief industrial engineer at Laclede-Christy division of H. K. Porter Company, Inc.

Fleming will be in charge of all industrial engineering at Laclede-Christy's plants. Previously, he was plant engineer for the Buffalo Steel division of H. K. Porter Company and industrial engineer for Kimberly-Clark Corporation.

Adds New Subsidiary

Philadalphia Pump and Machinery Company, Inc., has become a subsidiary of American Meter Company. President of the former company remains Joseph A. Eagan. Vice president is Wm. G. Hamilton, Jr., while William Ashby serves as secretary and treasurer.

Suppliers . . .

Three Join Hooker Staff; Plant Additions Announced

James M. Young, III, chemical engineer, and Robert P. Keating, chemist, have joined the process study group of Hooker Electrochemical Co. at Niagara Falls, N. Y.

At the same time, Gerald L. Glespen joined the Sales department at Niagara Falls as a sales analyst.

Young has been associated with the Mellon Institute of Industrial Research, Pittsburgh, as a research associate. Keating, prior to his appointment, was a lieutenant in the U. S. Navy.

Hooker also announced that new features have been added to the company's

Yes, dehydration of vapor and liquid feed stocks in petrochemical processing is best accomplished with superior drying efficiency by use of FLORITE DESICCANT.

Most economical of the granular drying agents, Florite has a longer service life, gives a low dew point depression, and aggressively resists "poisoning effects" which permanently destroy adsorption qualities.

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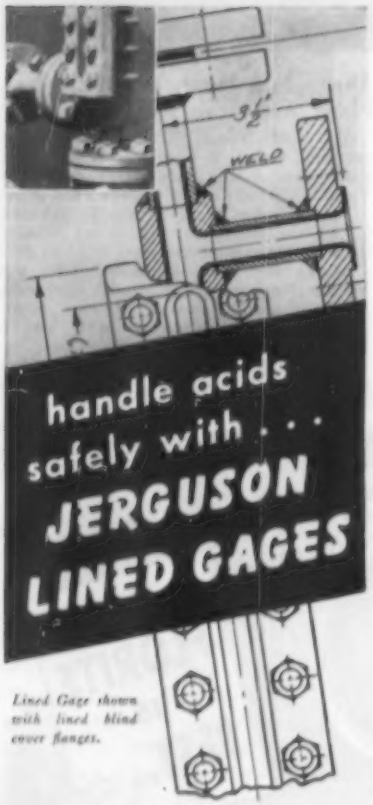
For more data on advertised products, use Readers' Service Cards, last page.



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To meet your constantly increasing variety of demands, Jerguson engineers, working closely with the men in the Chemical and Petrochemical Fields, have developed a complete line of sound, dependable liquid level gages, valves, and specialties in various metals and synthetics to handle corrosive liquids and gases.

Jerguson Gages keep you out of trouble, and they save you time and money. Send for drawing GD-431 on Lined Gages, or send your requirements.

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Suppliers . . .

new plant at Montague, Mich. Among them:

- Evaporation equipment to produce 73 percent caustic soda, in addition to 50 percent caustic, as planned earlier.
- Taller boiler house chimney to insure a very high degree of dissipation of any smoke to keep the atmosphere free of polution.

Hercules Powder Revamps Naval Stores Department

The Naval Stores department of Hercules Powder Company has been reorganized to include two assistant general managers and three new divisions and division managers.

Arthur Langmeier, assistant general manager of Naval Stores since 1952, will be responsible for production and development. G. Fred Hogg, newly appointed assistant general manager, will be responsible for sales under the reorganization plan.

The three new divisions and their managers are:

Agricultural Chemicals division, Richard T. Yates, manager; Pine Chemicals division, H. M. Wendle, manager; Oxychemicals division, Donald H. Sheffield, manager.

The positions of director of sales and assistant directors of sales in this department will be eliminated. Dr. R. S. George will become director of development under the reorganization, reporting to Langmeier.

A new Hercules plant involving new fields in the chemical industry will be put into operation next month by the Naval Stores department when the Higgins plant at Gibbstown, N. J., begins the production of synthetic phenol and acetone.

Hogg has been director of sales for Naval Stores for the past 11 years. Yates has been assistant director of sales for the Naval Stores department since 1945. Wendle served as assistant director of sales for Naval Stores for over two years prior to his new appointment. Sheffield has been assistant director of operations for the department since 1952, and Dr. George has been manager of development for the department since the same year.

Hammond Iron Works Makes Tentative Expansion Plans

A tentative agreement has been reached between Hammond Iron Works, of Warren, Pa., and Henry Sears & Company, of New York, to form a new company, as yet unnamed, which will carry on and expand the present business, products and facilities of Hammond Iron Works.

The new company will be built around the present Hammond personnel, organization and facilities, and will be augmented to provide greater service to general industry.

Bristol Expands at Waterbury

The Socket Screw Sales and Application departments of The Bristol Company have moved into a new office building addition recently completed at the company's offices at Waterbury, Conn.

Construction is nearly completed on an expansion of the company's manufacturing plant at Waterbury. Heat treating facilities at the plant have also been recently increased.

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Suppliers . . .

De Laval Promotes Two To Top Engineering Positions

Haverstick

Engvall

Harry Engvall, formerly chief engineer of the Turbine and Gear departments of De Laval Steam Turbine Company, Trenton, N. J., has been promoted to executive engineer. His former duties have been assumed by John S. Haverstick, who has been serving as chief research engineering since 1953.

Oakite Representatives Meet

Ninety-one technical service representatives from the Eastern and Canadian divisions of Oakie Products, Inc., met in New York recently to share industrial cleaning experiences and to hear company chemists describe the properties of materials recently introduced. Features of the three-day conference were the informal

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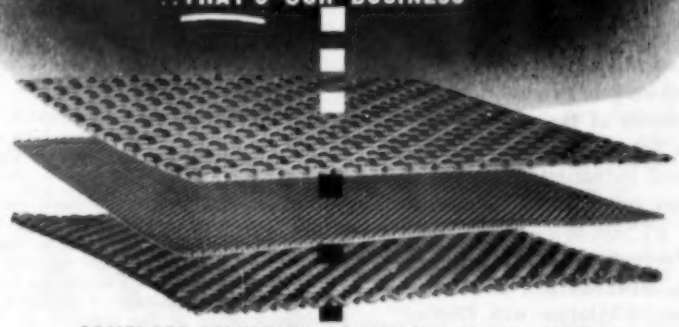

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No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

All Types of Insulation

Felted Asbestos
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For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

discussions in which the representatives reported on the problems they encountered in plants and the sometimes unorthodox ways in which they solved them.

Wolverine Key to Rasori

Ferruccio Rasori, of Kolostat Heating System, Ltd., Montreal, Canada, was recently presented the 1954 Wolverine Diamond Key Award by Wolverine Tube, Division of Calumet & Hecla, Inc. The award, made annually since 1940, is given for outstanding technical papers in the refrigeration field. Rasori won the award for his article, "Cooling Potential versus Specific Enthalpy."

Carbide Appoints Four

Four new assistant district sales managers have been appointed by Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation.

R. A. Corio has been appointed to the Newark district; R. J. Hughes to the Philadelphia district; D. F. Swartz, Jr., to the Baltimore district, and D. H. Merry to the Chicago district.

Bonney Forge Elects Two

Spencer M. Mieras and Kenneth W. Foust have been elected to the board of directors of Bonney Forge & Tool Works, Allentown, Pa. In addition, Mieras was elected to the post of executive vice president.

NEW BOOK ANNOUNCEMENT...

Off the press early in January—Order your copy Now for shipment immediately upon issuance . . .

The Chemistry of Petrochemical Reactions

By LEWIS F. HATCH, Ph.D.
Professor of Chemistry
University of Texas

This 192-page, completely indexed volume is the only thorough and exhaustive treatise on the basic chemistry of reactions and processing of those products and intermediates popularly classified as petrochemicals.

A completely contemporary study, this book is an immediate and valuable reference for anyone engaged in either the chemical or refining industry.

In addition to the technical data, valuable commentaries on end use and market of many significant chemicals are presented in such manner as to make this book a practical working manual.

This new book is a complete presentation of the material originally published as an 18-part series in *Petroleum Refiner*. Revised to date by Dr. Hatch, these current and authoritative studies on petrochemicals are now indexed for easy reference by subjects or products.

Typical chapter headings include: Production and Reactions of Butadienes, Oxidation of Hydrocarbons, Nitration and Sulfonation of Paraffin and Aromatic Hydrocarbons, Alkylation with Olefins.

PRE-PUBLICATION PRICE: $4.50 A COPY

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THE GULF PUBLISHING COMPANY
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ALCO Buys Pipe Fabricator And Opens New Dunkirk Plant

American Locomotive Company has concluded negotiations for the acquisition of the business, plant, machinery, equipment and inventories of Central Pipe Fabricating & Supply Company of Cincinnati, Ohio. ALCO takes over the company from its joint owners, H. K. Ferguson Company of Cleveland and Associated Piping and Engineering Company of Compton, Calif.

The new plant property consists of two buildings on 16½ acres of land in an expanding industrial area some 20 miles north of Cincinnati. The plant has a present capacity of approximately 200 tons of prefabricated process and power piping a month, ranging in size from 2½ inches up to 24 inches.

ALCO will begin improving and expanding the present plant facilities immediately. Manufacturing space will be greatly increased, machine tools and heat treating equipment installed, and a railroad siding constructed.

ALCO's expansion plans were meanwhile moving in other directions at Dunkirk, N. Y., where the company has completed industry's largest capacity plant for the commercial application of chemical nickel-plating.

Company Changes

John A. Field has been appointed vice president of **Carbide and Carbon Chemicals Company**, a Division of Union Carbide and Carbon Corporation. In this capacity he will be responsible for sales development and related activities including the companys fellowships at Mellon Institute, in Pittsburgh. Field recently returned to the company after a six-month leave of absence to act as assistant administrator of the Business and Defense Services Administration, U.S. Department of Commerce . . . **Fred Raible**, formerly a sales representative for **The Trane Company** in its Pittsburgh office, has been named manager of the West Hartford, Conn., office.

Cedric Beebe has joined the staff of the Application Engineering group at **Liston-Becker Instrument Company**. Beebe was formerly in charge of the physical analytical laboratory of the Koppers Company in Pittsburgh . . . **J. L. Parker**, Southwestern representative of **The Girdler Company's** Gas Processes division, has moved his office to 301 Wright Building, Tulsa.

C. A. Olsen, president of C. A. Olsen Manufacturing Company, has been elected to the board of directors of **York Corporation.**

George W. Kessler has been appointed chief engineer of **The Babcock & Wilcox Company's** Boiler division. He formerly served as an assistant chief engineer of the division . . . **Ray E. Fleeson** has been appointed to the sales staff of the Chicago district office of the Babcock & Wilcox' Tubular Products division. Since 1946 Fleeson has been in charge of the Cleveland sub-office of the Beaver Falls, Pa., district sales office.

William F. Tiernan, Jr., has been appointed director of purchases of **Catalytic Construction Company**, succeeding John T. Hoffman, recently deceased. Tiernan has been serving as assistant to the vice president in charge of engineering . . . **Dr. J. Peter Kass** has resigned as director of research at **Atlas Powder Company** but will continue to serve as a special con-

serving the Foundry needs of the Petroleum Industry

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Today, more than ever, the needs of the Petroleum Industry are more varied and exacting than ever before. And today, better than ever, Service Foundry engineers stand ready to assist you, to render the quality workmanship that has made their name famous throughout the Oil Industry . . .

SERVICE FOUNDRY a division of **AVONDALE MARINE WAYS, Inc.**

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Flowrites of various sizes

Air erosion of tube inlets can be combatted by Flowrites, sometimes called "inserts" or "wearing sleeves." Flowrites serve as a replaceable wearing section and are fitted to the inlet ends of tubes.

Fiber Plugs

The right type of tube plug will eliminate many operating difficulties. Only fiber plugs have proven completely satisfactory. In stock for all standard tube sizes.

The "Conseco" Specialties shown here are a few of the many we have developed to simplify maintenance, reduce costs and step up performance in your steam plant. We carry these items in stock in standard sizes for prompt delivery, or special sizes can quickly be made to order. Descriptive Bulletins sent on request.

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Retubing Condensers
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Air Ejectors
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Bulletins Available for Above Items

Conco Gun and Plugs

For slime, algae, vegetable matter or soft flaky scale deposits, use the hydraulically operated Conco Gun and Plug. Can be fitted with adapters and plugs for any size tube.

Bevel Gear Universal Joints

Bevel Gear Universal Joints are designed and built to give positive transmission of torsion regardless of shaft angle. A simple, flexible and economical solution to the problem of shaft line-up.

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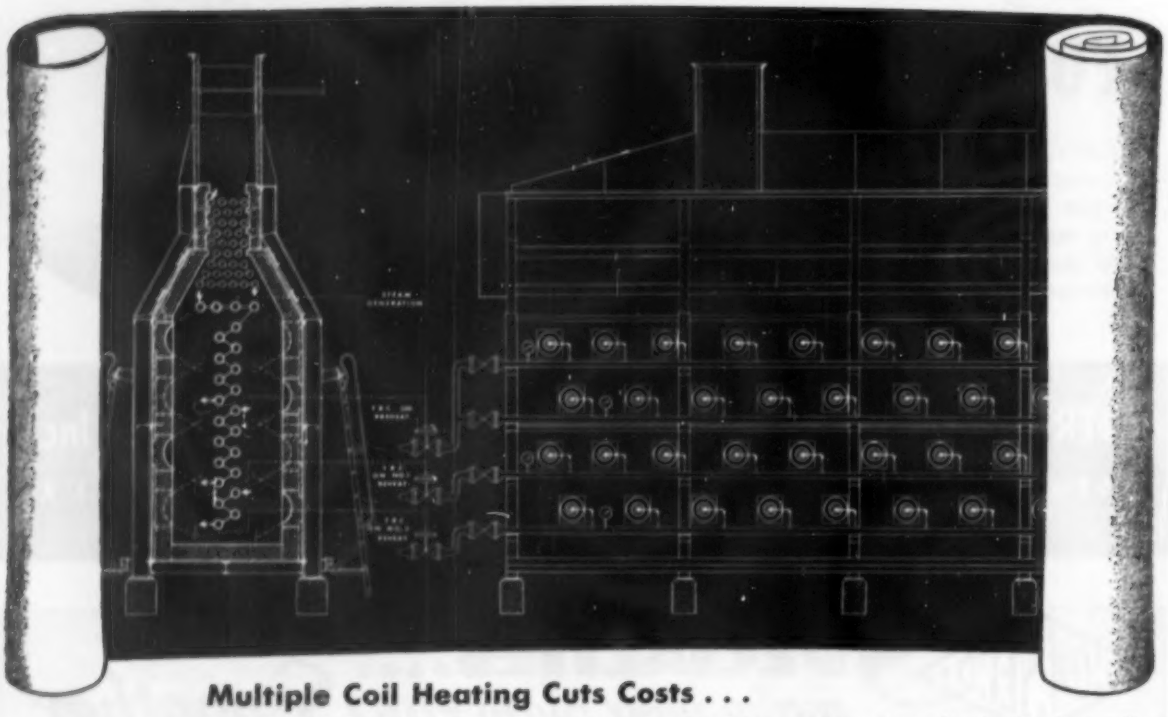
ONE HEATER DOES JOB OF THREE

with SELAS *Zone Control*



Multiple Coil Heating Cuts Costs . . .
Is More Efficient . . . Requires Less Space for Catalytic Reforming

● Zone Control of Selas Gradiation Heaters permits independent operation of more than one coil in a single radiant setting. By proportional variation of absorption rates in accordance with maximum allowable tube wall, film or process temperature—whichever is limiting—each section of the heating surface is more effectively utilized . . . thereby minimizing residence time and pressure drop.

Selas Gradiation Heaters are currently in operation in most of the major catalytic reforming processes and provide:

- Compact heating units with multiple coils and absolute temperature control in a single radiant chamber.
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Where two or more process streams require separate heating you'll find it worthwhile getting the facts on Selas Gradiation Zone Control. Let us send you our bulletin on selection of heaters for petroleum refining.

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REPAIR LEAKS
QUICKLY—PERMANENTLY.

SKINNER-SEAL PIPE JOINT CLAMPS stop leaks at joints. Put on under pressure—without interruption of service. Quick, simple, lasting repair. Sizes 1/2" to 24" incl. in stock.

SKINNER-SEAL COLLAR LEAK CLAMP—designed to stop every type of collar leak in oil and gas lines. Sizes: 2" to 13" inclusive.

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Suppliers . . .

sultant to the company. Dr. Robert S. Rose, Jr., now associate director, has been named acting director of the Research department.

Worthington Names Feldmann Executive Vice President

As a result of recent changes at Worthington Corporation (see first page of this section), Walther H. Feldmann, vice president in charge of sales for the past four years, has become executive vice president. He succeeds Edwin J. Schwanhausser, who has been elected president.

Feldmann

Kehane

Butcher

Thomas J. Kehane, formerly assistant vice president and general sales manager, has succeeded Feldmann as vice president in charge of sales.

Charles A. Butcher has been named vice president for planning. He joined Worthington in 1950 as assistant to the vice president.

General Precision Equipment To Control Griscom-Russell

Under the terms of an agreement with a substantial majority of the shareholders in The Griscom-Russell Company, Massillon, Ohio, General Precision Equipment Company, New York, will exchange a portion of its stock for stock in Griscom-Russell. The agreement, if consumated, will result in a transfer of control to General Precision Equipment.

Griscom-Russell, founded in 1912, is a leading manufacturer of heat transfer equipment and water purifiers for the petroleum, power and chemical industries and for naval and merchant vessels. Net sales in the first nine months of 1954 were $10,740,000.

Dow Department Appoints Two Field Representatives

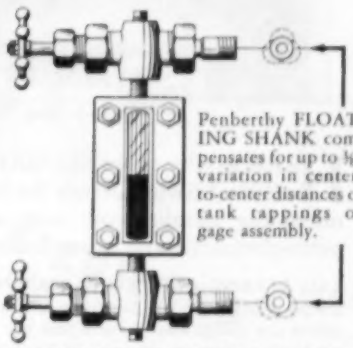
Two field representatives to be in charge of technical assistance in the industrial uses of plastic coatings on the West Coast and in the Southwest have been appointed by the Plastics department of The Dow Chemical Company.

William B. Guerrant will handle coatings technical service activities in Georgia, Florida, North Carolina, South Carolina and Alabama, with headquarters in the Dow Atlanta, Ga., office. Roy C. Simon has been assigned like duties on the West

PENBERTHY GAGE VALVES WITH
FLOATING SHANK
SAVE TIME and TROUBLE

Take a look at the tail pipe of the valve pictured here. Notice that it is adjustable in relation to the body of the valve.

This "floating" feature adds flexibility in mounting. It compensates for inaccurate center-to-center gage assemblies or variations in tank tappings . . . up to ⅛". Since a normal gage and valve assembly involves four threaded connections, the time saved in installing is appreciable. In addition, mounting stresses are eliminated.



Penberthy FLOATING SHANK compensates for up to ⅛" variation in center-to-center distances of tank tappings or gage assembly.

The FLOATING SHANK principle is a patented feature available only on Penberthy Gage Valves and at no extra cost. Ask your supplier to furnish these valves for *all* your gage requirements—new installations and replacements. Use the coupon to obtain detailed information on the Penberthy line of Liquid Level Gages and Gage Valves.

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PENBERTHY INJECTOR COMPANY
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Please send Catalog 835 to:

Name..... Title.....
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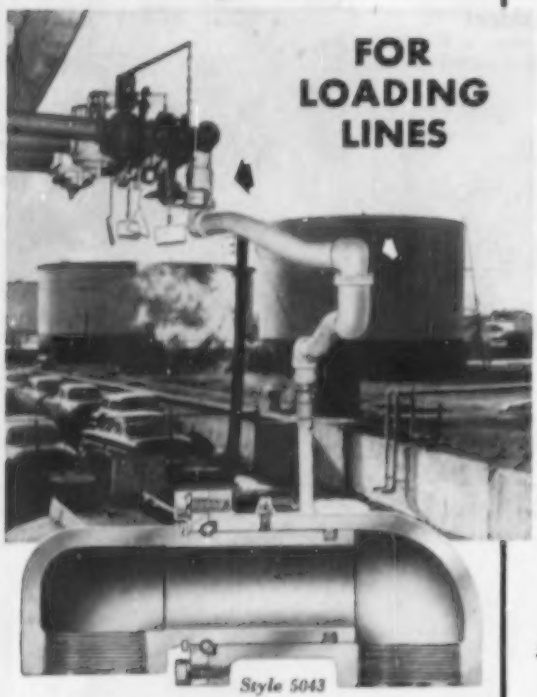
BARCO Swing Joints



HERE is why users like BARCO'S new *all-steel* Swing Joints for loading and unloading gasoline, oil, lube oil, LP gas, petro-chemicals and other fluids:

BALL BEARING AND O-RING EQUIPPED—In Barco Swing Joints, the ball bearings do not fall out when joints are taken apart! Long bearing provides adequate pipe support. *Special O-ring seal eliminates frequent gasket replacement.* Seals on pressure or vacuum. Leakproof service over wide temperature range, −40°F. to 225°F.

LONG LIFE—New *"Bar-Moly"* dry lubricant process gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.

EASY MAINTENANCE—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field. Frequent greasing not required to maintain sealing.

MANY STYLES—The Barco line is complete with single swing, double swing, and counter-balance styles to meet every need. Sizes 2", 2½", 3", 4".

BARCO MANUFACTURING CO.
5428 HOUGH STREET
Barrington, Illinois
Worldwide Sales and Service

For complete information on Barco Swing Joints, ask for a copy of Catalog 400.

Suppliers . . .

Coast, and will make his headquarters at the company's Los Angeles office.

Guerrant joined Dow in 1950, Simmon in 1952.

General Electric Announces Major Executive Changes

Major changes in its executive office organization have been announced by General Electric Company. They include:

Formation of the Distribution Group composed of the Apparatus Sales division, the General Elecrtic Supply Company, International General Electric Company and the General Electric Credit Corporation. The Affiliated and Foreign Companies Group is discontinued.

Appointment of executive vice president Henry V. Erben as group executive in charge of the new Distribution Group and of executive vice president Robert Paxton to succeed Erben as group executive in charge of the Apparatus Group. Canadian General Elecrtic Company becomes a part of the Apparatus Group.

Election of John W. Belanger as an executive vice president and appointment of Belanger as group executive in charge of the Industrial Products and Lamp Group, succeeding Paxton. The X-Ray department becomes a part of the Industrial Products and Lamp Group.

The changing of the name of the Defense Products Group to the Atomic Energy and Defense Products Group and the assignment of group executive responsibility to vice president Cramer W. LaPierre, who succeeds Belanger.

Indicative of the significance the company is placing on atomic energy activities is the announcement that the Defense Products Group will now be known as the Atomic Energy and Defense Products Group. LaPierre, who has been assigned group executive responsibility, also will continue as general manager of the Aircraft Gas Turbine division which, together with the Atomic Products division and the Aeronautic and Ordnance Systems division, will comprise the group.

Group responsibilities for the Appliance and Electronics Group remain under executive vice president Roy W. Johnson.

New Barge Will Transport Shell Anhydrous Ammonia

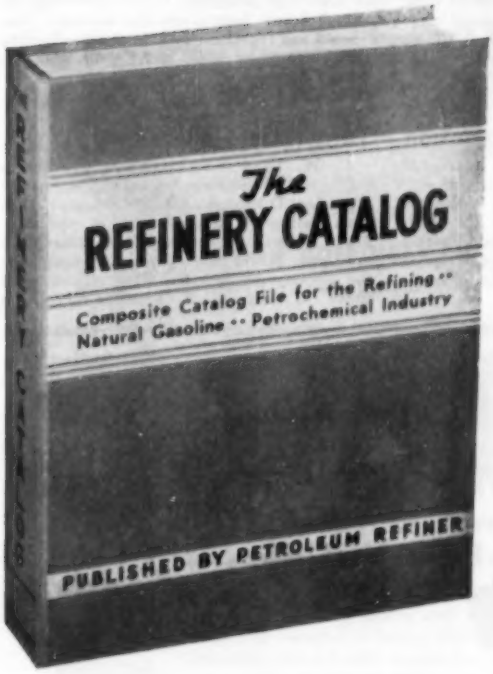
The largest barge ever constructed for the transportation of anhydrous ammonia has been launched by Bethlehem Steel Company at its Beaumont, Texas, yard. Specifically designed for its unique task and featuring a ship-shaped, rather than barge-like, bow, the vessel is part of a multimillion dollar program of Shell Chemical Corporation to supply farmers and industries of the Pacific Northwest with the compound.

The craft bears the name Ammonia Mariner and is under construction for Tidewater-Shaver Barge Lines of Portland, Ore. Tidewater-Shaver will use it to transport ammonia from Shell's plant at Pittsburg, Calif., to a new Shell terminal at Portland. The barge has an over-all length of 252 feet, beam of 48 feet, depth of 18 feet and a capacity of 1680 tons.

Aloyco Marks 25 Years

Alloy Steel Products Company, Linden, N. J., is now commemorating its twenty-fifth anniversary as producers of valves. Aloyco recently completed a substantial

BASIC SOURCE BOOK on Equipment – Materials – Processes... for the REFINING INDUSTRY


The
REFINERY CATALOG
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SAVE MONEY

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For fast, accurate buying decisions, reach for the Refinery Catalog. Hundreds of manufacturers have their equipment and services catalogs filed between its covers. Here's the information you need for adequate comparisons. Cross-Indexed for easy reference.

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Watch for this sign of Customer Service

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THE UNIVERSAL EQUIPMENT GUIDE FOR REFINERY BUYERS

For more data on advertised products, use Readers' Service Cards, last page.

expansion of its facilities, making it the world's largest manufacturer of corrosion-resistant valves exclusively.

Conoflow Holds Conference For Sales Representatives

A sales engineering conference was held recently by Conoflow Corporation for its representatives at the company's executive offices in Philadelphia.

Twenty-seven sales personnel from manufacturers' representatives located all the country attended the conference. Included in the three-day session were addresses outlining Conoflow's policies and principles, graphic engineering talks and demonstrations, and a presentation of details of construction, operation and application of company products.

Tuloma Builders Plans New Headquarters Near Tulsa

Tuloma Builders, Inc., of Tulsa, has announced plans for new, three-building headquarters southeast of Tulsa. One of the buildings will be a two-story structure, and will house offices and work areas for the firm's engineers. The other buildings will be used for warehousing, equipment maintenance, welding and fabrication.

The office building will contain approximately 7000 square feet of floor space, and the two warehouses, shop and fabrication buildings will have a total of 8000 square feet of space.

Edwards Group Talks Sales and Production—

New developments in the production and use of wire rope came under discussion at the recent annual sales meeting of E. H. Edwards Company, South San Francisco, Calif. Sales efforts on behalf of the company's Sterling Steel wire rope were also planned for the coming year at the meeting, which was attended by: left to right, back row—Paul Sanderson, Los Angeles regional manager; Fred Butler, Portland regional manager; Ralph Brown, Seattle regional manager; Russ Reeves, Houston regional manager; Rudy Steinbruck, South San Francisco; and, front row—Sterling Edwards, president; Russell Hendrick, vice president in charge of sales, and Kermit Williams, executive vice president and treasurer.

Sales Head Named in Expansion

Charles J. Schleeweis has been appointed sales manager in connection with a general expansion of facilities at Johnston Pump Company. For the past six years Schleeweis, as manager of Johnston Pump's export sales, has traveled extensively in Latin America, India, and the Middle East.

Turner Gets New Post

C. W. Turner, for the past five and a half years supervisor of dairy industries sales for Diamond Alkali Company, has been promoted to manager of specialty sales. He will be responsible for directing and correlating merchandising programs for Diamond's branch sales offices with those of independent chemical merchants

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What's your product . . . gasoline, butane, anhydrous ammonia? No matter what it is, Lubbock Machine and Supply Company can manufacture a transport tank that's engineered for your product and priced for your budget. Your transport tank from Lubbock Machine and Supply will carry the maximum pay load for your state, fit your individual trucks, and conform to state highway and ICC regulations. Write today for information regarding prices, pay loads, our easy budget plan, etc.

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JIGSAW STEEL PUZZLE

Nearly 800 tons of steel by Dollinger went into the erection of this new Suntide Refinery. Structural steel framing, tower platforms, walkways and yard pipe supports were delivered in proper sequence—on time—with each integral part accurately fabricated. The result . . . another economical erection job with steel by Dollinger. The Lummus Co. was designer and erector.

STEEL BY DOLLINGER

For more than 50 years quality producers of structural steel and plate steel.

AROUND THE WORLD

JOHN DOLLINGER, JR., INC.
BEAUMONT, TEXAS

LEKTROMESH

THE UNIQUE SOLID-METAL SCREEN

Distinguished for its

★STABILITY in use
★UNIFORMITY of Hole Size
★WORKABILITY in Manufacturing Processes
★DIVERSITY of Applications to Research and Production

Electro-deposited in pure copper, pure nickel, or nickel-on-copper — in regular commercial production with counts from 25 to 400 per inch — in lengths up to 100 feet and widths up to 36 inches — with tolerances on hole size and thickness suitable for the most critical uses — LEKTROMESH is ideal for precise filtration, for fabricated products such as fuel filters and electronic shields, even for distinctive decorative screens with an integral pattern. For full details let us send our Bulletin on LEKTROMESH. Address Department 16

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DIPPING BASKETS
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RESISTANCE WIRE
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STRAINERS - FILTERS
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Now! for greater safety

New Safety GRIP-STRUT stair treads custom made to your exact size . . . Here for the first time is a really SAFE stair or ladder step, combining the proven features of Safety GRIP-STRUT material with a double locked carrier plate to provide additional safety over present types.

Made to your own individual size at the factory, the cost is amazingly low . . . you can buy a standard 18" stair tread in lots of 50 for $2.48 each. Prices proportionately lower in greater quantities.

Distributors in all principal cities. Consult your classified telephone directory.

GRIP-STRUT division
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Manufacturers since 1914
4008 S. Princeton Ave. • Chicago 9, Illinois

for accurate temperature indication

use **DILLON**

screw-in thermometers

low cost—many uses

tanks
boilers
kettles
stacks
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ducts, etc.

Simple construction makes Dillon stainless steel DIAL THERMOMETERS both low in cost and easy to use. Can be screwed into equipment or floated on liquids. May be inserted directly into molten lead. DIALS ARE EASY TO READ EVEN FROM A DISTANCE. (2¼", 3" and 5" diameters.)

All popular F. and C. ranges PLUS special ranges to order. Stems from 3" to 72". Pressure-proof for over 3476 P.S.I. Moisture sealed. Overload protected. *Guaranteed Accurate.*

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Write for your free copy of bulletin No. 3. Gives complete engineering data and price information.

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14628S Keswick Street, Van Nuys, Calif. (Suburb of Los Angeles)

Gilbarco

West Springfield, Mass.
Toronto, Canada

Gilbert & Barker Mfg. Co.
West Springfield, Mass.

Gentlemen:

Please send me brochure on the Gilbarco Electronic Tank Gauge.

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NOW YOU CAN MAINTAIN 100% GREATER ACCURACY

This coupon will bring you full information on a revolutionary

NEW ELECTRONIC TANK GAUGE

The new Gilbarco Electronic Tank Gauge, the result of years of laboratory research and field testing, actually *measures electronically*. No adjustments needed for varying specific gravities or viscosities. Can be installed *without* taking tank out of service. Liquid is measured with a degree of accuracy never before approached by any other method of gauging. And equally accurate readings can be made at remote points. Get full information on this revolutionary new gauge *today*.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Worthington Shows Machinery—

An education exhibit of basic industrial machinery was opened to the public last month by Worthington Corporation at 99 Park Avenue, New York.

Nearly all of the displays in the unique exhibit, part of which is shown above, are of the visitor-participation type where, by operating the models themselves, the visitor gains an understanding of various machines and how they are used.

A feature of the exhibit is a three-dimensional diorama, "Worthington City." Illuminated color photographs above each related activity in the composite model show how Worthington products are used in industrial operations.

who distribute its specialized detergents and related chemicals in other strategic locations.

Hercules Powder Elects Fulenwider Vice President

Election of a new vice president and the appointment of two department general managers have been announced by Hercules Powder Company.

John J. B. Fulenwider, general manager of the Hercules' Cellulose Products department and a member of the board of directors since 1945, was elected a vice president, and member of the executive committee.

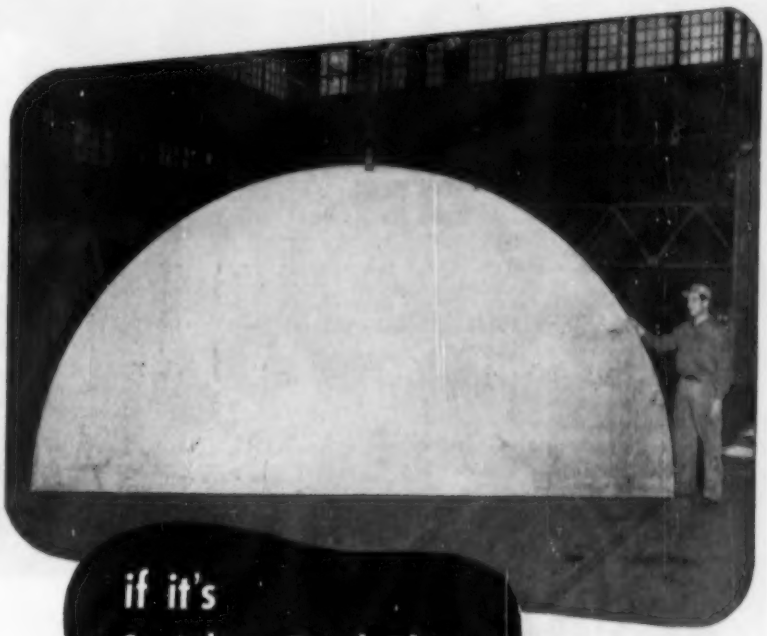
Named to succeed Fulenwider as general manager of the Cellulose Products department was Elmer F. Hinner, a member of the board since 1952 and general manager of the company's Virginia Cellulose department since 1950.

Edward G. Crum, assistant general manager of the Cellulose Products department, was named general manager of Virginia Cellulose to succeed Hinner.

Honeywell Buys Doelcam

Minneapolis-Honeywell Regulator Company has purchased all of the outstanding capital stock of Doelcam Corporation of Boston, Mass., manufacturer of precision instrument and conrtol equipment for aircraft and industry uses.

The New England firm, which has a main plant and administrative offices in Boston and another plant and engineering



if it's
Stainless Steel Plate
any size . . any shape
you *save* at
G. O. CARLSON, INC.

SAVING anything is a tall order today. However, at G. O. Carlson, Inc. there's a saying that goes like this . . . "we make it easy for our customers to do business with us." This means that Carlson customers save time, save effort, save money. How? First, through Carlson experience—years of experience in handling stainless steels exclusively. Then, Carlson specialists know how to make the most out of every pound of material and efficiently use Carlson's special equipment for cutting stainless steel to shape. And finally, customers pay only for what they want—*and nothing else!*

The segment of a tank head illustrated is typical. Made of 1" thick, Type 302 stainless steel, the head blank measures 210" in diameter and weighs approximately 9900 pounds. So accurately was this segment produced that no "truing up" of the abrasive cut straight edge was required prior to welding two segments together.

It is this *unique ability* in handling *difficult* work that makes customers enthusiastic about the G. O. Carlson, Inc. services. For your next job in stainless steel plate . . . *let Carlson do it.* Your inquiry will receive prompt attention.

Stainless Steels Exclusively

G. O. CARLSON, INC.

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

For more data on advertised products, use Readers' Service Cards, last page

G-R fin-fan

more *than ever your best buy in*

AIR-COOLED HEAT EXCHANGERS

more *Applications*

The **fin-fan** exchanger is readily adaptable to practically every condensing and cooling application, particularly when the use of cooling water involves problems of supply, cost, scale or corrosion. Such flexibility is just one of many features, which make the G-R **fin-fan** your best investment in air-cooled apparatus.

more *Advantages*

Many important design and construction advantages are incorporated in the **fin-fan.** These include 100% effective cooling surfaces; maximum heat transfer afforded by exclusive G-R K-Fin Cooling Sections; fully prefabricated structure; predrilled supports, providing for addition of future units; *plus* bell-type fan ring for maximum efficiency with minimum horsepower required for fan.

more *Installations*

More square feet of K-Fin tubing, which forms the heat transfer surface, are being used in more types of air-cooled installations than any other design. Reason? Dependable ratings, design and workmanship backed by over 85 years of specialized experience in building quality heat transfer apparatus for varied services all over the world.

more

Dependable because completely G-R

The new G-R **fin-fan,** *completely G-R,* can be depended upon for structural strength, peak operating efficiency, ease of installation, operation and maintenance. It is a complete self-sustained unit combining the best transfer service available with tested and proved air circulation equipment. As a result of exhaustive tests conducted on the complete equipment over a six month period G-R can offer you *guaranteed performance* based on actual test data. This is just one more important reason why the new G-R **fin-fan** is your best buy in air-cooled heat exchangers.

GR331

G-R HEAT TRANSFER APPARATUS

THE GRISCOM-RUSSELL CO., MASSILLON, OHIO

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

fin-fan Air-Cooled Heat Exchanger

Suppliers . . .

laboratories in Newton, Mass., would be operated as a new division of Honeywell. There will be no change in the management, headed by John J. Wilson, president and founder of Doelcam.

Bailey Meter Sets Up Two New District Offices

Byers

Krusemark

New district offices have been established by Bailey Meter Company, Cleveland, Ohio, at Dallas, Texas, and Memphis, Tenn.

F. D. Krusemark is manager of the new Dallas office, which covers northern Texas and northwestern Louisiana. R. E. Byers is manager of the Memphis office, which includes western Tennessee, northern Mississippi and all of Arkansas.

Chapman Valve Elects Cochran President, General Manager

Ernest Cochran, formerly executive vice president, has been elected president and general manager of The Chapman Valve Manufacturing Company, succeeding John J. Duggan, recently deceased.

Cochran has been with the company since 1916. He has served in numerous capacities, including manager of sales and engineering, vice president and, since February, 1954, executive vice president.

Harold G. Dickey, president of Moore Drop Forging Company, Springfield, Mass., has been elected to the directorate of Chapman Valve.

New Research Center Opened

A new research and product development center has been opened in Denver, Colo., by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. It will supplement research activities conducted at the division's main office and factory in Freeport, Ill. Wilbert Martin, assistant director of product research and development will be in charge of the new facility. About ten engineers and technicians will be employed.

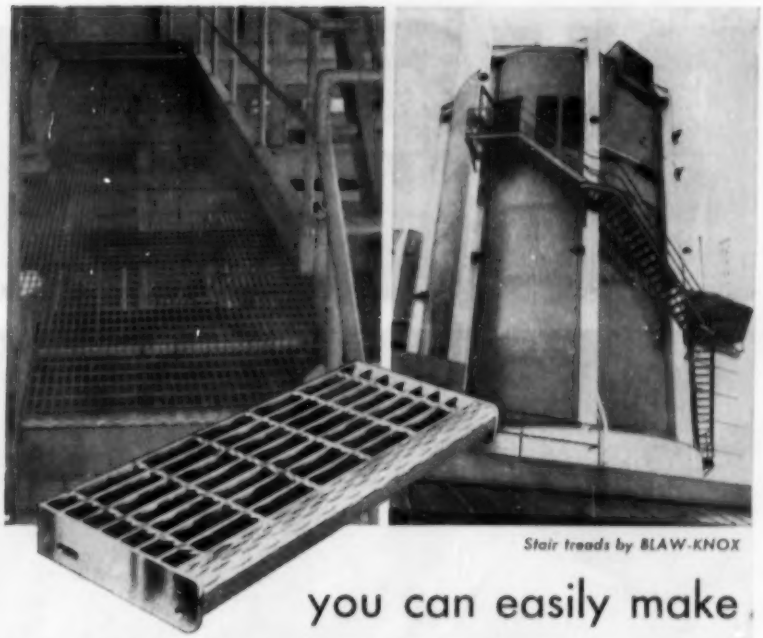
Trucks Get UL Approval

Clark Equipment Company, manufacturer of materials handling equipment, has received Underwriters' Laboratories approval and listing of its complete line of solid-tired industrial fork lift trucks powered by liquefied petroleum gas.

The approved line ranges in capacity from 2000 pounds to 7000 pounds.

Witco Elects Vaccaro

Michael D. Vaccaro has been elected vice president in charge of eastern sales



Stair treads by BLAW-KNOX

you can easily make

every step a safe step

Indoor or outdoor, you can rely on Blaw-Knox Stair Treads to provide the safety you want in your plant.

Designed for tremendous strength against impact, these stair treads are made with twisted cross bars and rolled diamond checkered plate nosing—as illustrated.

But, when desired, you can get treads with a twisted cross bar nosing or an abrasive nosing. And for specially slippery conditions we can supply you with serrated cross bar treads.

Just tell us what your application is and we'll offer our recommendations as to the best type of tread for your job.

Only Blaw-Knox Electroforged® Steel Grating and Stair Treads —have these five exclusive features:

1. **rigid one-piece construction—easy to install**
2. **all surfaces accessible—easy to paint**
3. **no sharp corners to clog—self-cleaning**
4. **maximum open area—for light and ventilation**
5. **non-slip twisted crossbar—safe footing**

A short note will bring you a copy of new Bulletin No. 2365-R —a dimensional sketch will bring you a quotation.

BLAW-KNOX

BLAW-KNOX COMPANY
2005 Farmers Bank Building • Pittsburgh 22, Pa.

BLAW-KNOX EQUIPMENT DIVISION GRATING DEPARTMENT

GRATING APPLICATIONS: floors • platforms • walkways • catwalks • stair treads • fan guards • shelving • and many other uses, both outdoors and indoors, for versatile steel grating.

For more data on advertised products, use Readers' Service Cards, last page.

RUGGED!

CHASE WAREHOUSE STOCKS: Houston,* Los Angeles, New Orleans, Tulsa**

*Handled by Standard Brass & Mfg. Co.
**Handled by Vinson Supply Co.

Chase® Antimonial Admiralty resists dezincification—adds years to heat exchanger tube life!

Chase Antimonial Admiralty Heat Exchanger Tubes contain the *right* amount of antimony needed to resist dezincification and other forms of corrosion. That's why *Chase* tubes last so much longer!

And antimony will *not* weaken the tube in other ways! That's why *Chase* tubes *stay* sound through years of adverse conditions in the field!

When you replace Heat Exchanger Tubes, or plan a new installation, get the benefit of *extra* years of service. Insist on Chase Antimonial Admiralty.

Learn more about corrosion problems, and how Chase can help solve them. Send for free Chase Condenser and Heat Exchanger Tube Booklet.

Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass & Copper (†sales offices only)

Albany†	Chicago	Denver	Indianapolis	Minneapolis	Philadelphia	St. Louis
Atlanta	Cincinnati	Detroit	Kansas City, Mo.	Newark	Pittsburgh	San Francisco
Baltimore	Cleveland	Grand Rapids†	Los Angeles	New Orleans	Providence	Seattle
Boston	Dallas	Houston	Milwaukee	New York	Rochester†	Waterbury

Suppliers . . .

for Witco Chemical Company. He was formerly eastern sales manager.

Cothran Wins Oakite Award—

W. W. "Wes" Cothran, left, receives the 1954 D. C. Ball Distinguished Service Award from John A. Carter, president of Oakite Products, Inc. Cothran has represented Oakite in Indianapolis for the past 21 years. The award, named in honor of the founder of the firm, is given annually to the Oakite technical service representative who has rendered "exceptional service to industry." Cothran received the plaque at the company's Midwestern technical sales conference held recently in St. Louis.

ACF Buys Equipment Firm

Engineering and Research Corporation, Hyattsville, Md., has been acquired by ACF Industries, Inc. The former company is engaged in the production of aviation and electronic equipment with some $24 million in orders on its books. It has a large plant and production facilities on a 232-acre plot of land within seven miles of Washington, D. C.

To Offer Related Processes

The Chemical Plants Division, Blaw-Knox Company, Pittsburgh, has been licensed to offer two related reforming processes developed by Hercules Powder Company, Wilmington, Del.

The hydrogen and olefins processes both utilize alloy tubes set virtually in furnaces of similar design operating at high temperatures.

Mexico Refractories Expands

Assets of the Niles Fire Brick Company, Niles, Ohio, have been purchased by Mexico Refractories Company. These assets are valued at about $3.5 million. Annual production capacity of Niles Fire Brick is more than 25 million silica and fire clay brick.

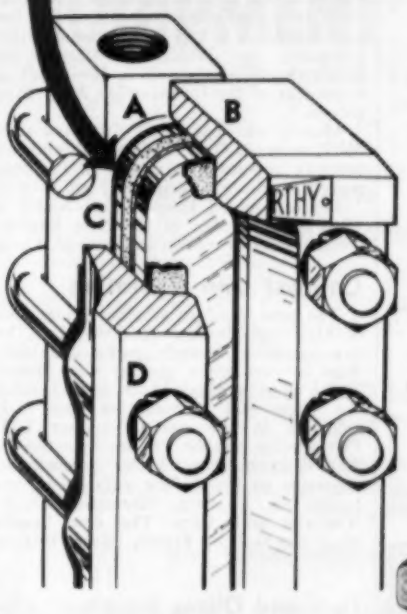
Graver Opens New Office

A new Texas district office has been opened in Houston by Graver Water Conditioning Company. It will be managed by James J. Hanratty, who has been with Graver many years, and will serve all of New Mexico and Texas except the northern part of the Panhandle.

Du Pont Reassigns Rogers

John D. Rogers has been named engineer on new product development for the

"RAISED FACE" OF PENBERTHY GAGES OFFERS EXCLUSIVE ADVANTAGES



A. Perfect alignment of frame with glass and gasket assured . . . leaks or glass breakage minimized.

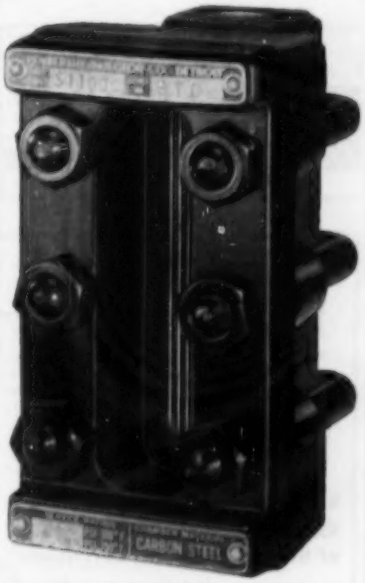
B. Cover completely encloses sides and ends of glass and gasket, thereby preventing blowouts and danger of accompanying hazard.

C. For high pressure service the close fit over raised face gland resists distortion of cover due to bolt loading stresses.

D. Drop-forged steel frame, heat-treated alloy steel liquid chamber and bolts withstand rugged service conditions.

In Addition to These Operating Advantages, Benefits in Field Service Include . . .

- Easy glass or gasket replacement and gage cleaning facilitated by fully accessible RAISED FACE.
- Correct alignment in reassembly.
- Repair of gasket surface without removing assembly from vessel.



Reason enough for you to investigate the use of Penberthy gages in your operation. Complete units and replacement parts are stocked by leading suppliers. Use the coupon on the facing page to obtain more detailed information.

There's Certain satisfaction in **PRODUCTS BY** PENBERTHY

- CYCLING JET PUMPS
- EJECTORS
- INJECTORS
- ELECTRIC SUMP PUMPS
- EDUCTORS
- EXHAUSTERS
- SYPHONS

For more data on advertised products, use Readers' Service Cards, last page.

Designers

• PIPING

• STRUCTURAL

To design new oil refineries and chemical plants. Please send your resume to our Personnel Department. Your letter will receive immediate and confidential attention.

C F BRAUN & CO

Engineers
Constructors

ALHAMBRA, CALIFORNIA

Thanks to

SAND-BANUM

Pure Colloidal Concentrate

There's No Problem in Safe—Certain—Economical REMOVAL and PREVENTION of Boiler Scale and Corrosion

MORE POWER — LESS FUEL
FEWER SHUT-DOWNS — LONGER EQUIPMENT LIFE

Stocked by Leading Supply Houses

AMERICAN SAND BANUM CO.
Established 1926
9 Rockefeller Plaza
New York 20, N.Y.

Suppliers . . .

Petroleum Chemicals division of E. I. du Pont de Nemours & Company. He formerly worked with refiners on automotive combustion problems as an automotive technologist.

Morey and Mounce Receive New Assignments at Inco

James B. Morey has been named in charge of the Cincinnati, Ohio, Technical Field section of the Development and Research division of The International Nickel Company, Inc. William S. Mounce has joined the division's staff in New York as a member of the Construction Alloy Steel section.

Morey, who has been with Inco since 1939, succeeds C. T. Haller, Jr., who was recently appointed in charge of the company's Pittsburgh Technical Field section.

Mounce joined International Nickel in 1946 as a member of the New England Technical Field section at Hartford, Conn.

Catalyst Unit Operating

The new catalyst manufacturing plant of Universal-Matthey Products, Ltd., began operations recently, just a little more than a year after ground was broken. Located on a 10-acre site near London, the plant will manufacture and make available in the sterling market UOP Platforming catalyst for use by refineries. The company has already entered into contracts to supply the catalyst to customers in England, Germany, France, Australia and Aden. The new London plant was built by Procon (Great Britain) Ltd.

Dorr and Oliver Merge

Dorr Company of Stamford, Conn., and Oliver United Filters Inc., Stamford, have merged under the name of Dorr-Oliver Inc., with headquarters at Stamford.

Represents Insul-Mastic

Runnels Paint Company, Seattle, Wash., is new selling and applying Insul-Mastic Corporation of America protective coatings in the Pacific Northwest.

Duncan Fraser Dies

Duncan W. Fraser, for 14 years chairman or president of American Locomotive Company, died December 20 at the Harkness Pavilion, Columbia-Presbyterian Medical Center in Manhattan. He was 79.

Fraser retired as board chairman early last year after having served with Alco for 56 years.

Henson, of Norton, Dies

William H. Henson, special representative of the Refractory division of Norton Company, died December 1 in Worcester, Mass. Since 1952, Henson had served as a representative on Norton products for use in atomic energy. A graduate of the University of Illinois, he joined Norton Company in 1928.

John Regan Dies

John J. Regan, owner of Philadelphia Steel & Iron Company, Conshohocken, Pa., died November 20.

M-C&S Sets Up New Quarters

New executive offices have been set up by Merritt-Chapman & Scott Corporation at 261 Madison Avenue, New York, to serve as administrative headquarters for the company.

Lukens to Make New Steel

Lukens Steel Company, Coatesville, Pa., has been licensed to manufacture "T-1" constructional alloy steel which was developed by United States Steel Corporation.

Cambridge Names Roche

Richard Roche, who has been associated with Cambridge Wire Cloth Company for the past 14 years, has been appointed personnel director of the company. For the last five years he has served as safety director.

GUNITE
Since 1915
CONCRETE
SAND AND CEMENT
"Placed by Air"

We have completed over 2800 exclusive GUNITE contracts including — LININGS ENCASING — INSULATING — REPAIRING NEW CONSTRUCTION.

Send for specifications and bulletins

See our catalog in Sweet's

GUNITE CONCRETE & CONST. CO.
1301 WOODSWETHER RD., KANSAS CITY 5, MO.
2016 W. WALNUT, CHICAGO 12, ILL.
3206 HOUSTON, HOUSTON 9, TEX.
St. Louis - Milwaukee & Twin Cities - Denver
New Orleans - Memphis

STEEL PIPE and TUBING

• LOW CHROME
• STAINLESS
• HASTELLOY
• CARBON

ALL SPECIFICATIONS — ANY SIZE

Write for Stock List
Send us your surplus lists

MIDCONTINENT TUBE SERVICE, Inc.
2308 Oakton St., Evanston, Ill., Davis 8-4030

FREE 8 pg. BROCHURE shows direct method of making accurate **PIPE LAYOUTS**

Free—8 pages of expert, clear information, charts and diagrams . . . worth a fortune to any **Welder, Pipe** or **Sheet Metal Worker, Layout Man, Foreman, Engineer,** etc. Explains famous "direct methods" of making **Pipe Bends up to 120°** on **any diameter** pipe or flat sheet metal. Also "T" Layouts, **Multi-Piece Bends, Roof-jacks, Angle Iron Layouts,** etc. . . . Shows how to find **Center Lines,** check layouts and finished work . . . **ACT NOW** . . . send postcard or letter, or clip out this ad and mail with your name and address to

INTERSTATE SALES CO.
123 E. 18 St. New York 3, N. Y.

Suppliers . . .

Air Placement Expands Sales

A new expansion program for the distribution and sale of its products has been announced by Air Placement Equipment Company. The new program will involve the establishment of additional dealer-distributorships in certain territories on a franchise basis. All sales will be made through these regularly established construction and equipment distributors.

Holds Refresher Course

Scovill Manufacturing Company recently held a two-day refresher course for its industrial hose sales specialists at Waterbury, Conn. To keep the salesmen posted on the latest developments in the field, heads of the company's production, research, marketing, sales, tool and development departments led discussions.

Appleton Appoints Two

I. W. Strong, assistant to the vice president in charge of sales at Appleton Electric Company, has been promoted to assistant to the president. Wade H. Schroeder, controller, was elected to the position of assistant treasurer of the company at the same time. Both posts are newly created.

Pritchard Moves Offices

J. F. Pritchard & Company has moved its offices to its own building at 4625 Roanoke Parkway, Kansas City, Mo.

HELP WANTED

Sales Opportunity

Well known Southwestern business firm needs a chemical engineer with refining background for sales position. If you are 25 to 40, have the desire to sell, are intelligent and willing to work hard, this job offers real money-making opportunity. In your reply, please give your complete education and business history, whether or not you would be willing to relocate. Address Box 190 - R Petroleum REFINER.

PETROLEUM REFINER Classified Ads

FOR SALE

EQUIPMENT SPECIALS!

Towers & Columns

8' x 28'	2—7' x 57' (400#)	5' x 62'
7'-6" x 56'	7' x 42'	4' x 72'
7'-4" x 70'	6' x 63'	4' x 47' (250#)
2'-6" x 60'	6' x 58' Chr. clad	3'-6" x 63'
2' x 45' (250#)	2' x 75'	2' x 60' (560#)

Heat Exchangers

2—1125 sq. ft. (850#)	5—360 sq. ft.
5—1660 sq. ft., Adm.	1—302 sq. ft., Cu-Ni, unused
1—1000 sq. ft.	4—260 sq. ft.
1—600 sq. ft., Adm.	1—245 sq. ft., Adm. (unused)
5—424 sq. ft., Adm.	5—Karbate 188,177 sq. ft., unused

Liquidation 7000 Barrel Refinery

Levelland, Texas

Consisting of Towers, Heat Exchangers, Tanks, Vessels, Pumps, Compressors, Ethyl Lead Plant, Complete Truck Loading Rack with Pumps, Meters, etc.

WIRE, PHONE, WRITE FOR COMPLETE DETAILS

BRILL EQUIPMENT COMPANY
4101 SAN JACINTO STREET, HOUSTON 4, TEXAS
New Telephone: LOcust 1351
A SINGLE ITEM OF A COMPLETE PLANT
Write, wire or phone us for complete information — Send us your surplus equipment lists today

GLASSES & GASKETS

ALL SIZES TO FIT YOUR GAGES & VALVES
ERNST WATER COLUMN & GAGE CO.
Send for Catalog, LIVINGSTON, N. J.

SITUATIONS WANTED

• CHEMICAL ENGINEER, five years processing large refinery, ten years resident engineer rapid growth refinery, petro-chemical processing. Box 189-R, c/o Petroleum REFINER, Houston, Texas.

HELP WANTED

• ENGINEERS for aggressive manufacturing company in midwest. Graduate engineers or engineering background, in design or development work for control equipment, used in oil and gas production. Organization also needs sales engineers experienced in above lines. Company offers excellent benefits with salary review every six months. Salary range $5000 to $7000. Company pays our service charges. All information confidential. Send resumes to CHAS. J. LOVELESS PERSONNEL SERVICE, 616 South Main, Tulsa, Oklahoma.

HELP WANTED

SENIOR FURNACE • ENGINEER

The design of furnaces to improve process service requires exceptional training and ability. We'd say the minimum was an ME or ChE degree, 8 years background in furnace design, and a thorough knowledge of heat transfer fluid flow, chemical reaction, metallurgy and strength of materials as applied to furnace design.

The ability to recommend desirable process changes, to develop new designs and design methods requires additional talents as well as initiative.

If you can meet these exacting qualifications, we'd like to meet you. The result can be mutually profitable.

Box #538, Room 1201
230 West 41 St., New York 36, N. Y.

Use Refiner classifieds for quick results!

For more data on advertised products, use Readers' Service Cards, last page.

OAKITE *Maintenance* CLEANING

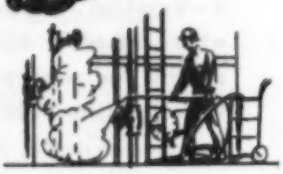
helps maintenance crews save time, cut costs, keep equipment operating efficiently

Specialized Oakite cleaning, descaling and related materials plus Oakite up-to-date methods are widely used in all branches of the petroleum processing industries. These specialized materials and methods . . . developed through more than 45 years of experience . . . are designed to provide you with the best in all round cleaning efficiency. What is more—all Oakite materials are backed by a binding guarantee. Your interests are fully protected.

Here are four maintenance jobs, typical of the type of many, Oakite is called upon to do every day of the year. These cleaning operations are fully covered in our free booklet "What Petroleum Men Should Know to Simplify Cleaning". Send for a copy.

1 **TOWER CLEANING.** Oakite lists a wide variety of compounds for removing waxes, resinous products, iron sulfides, oxides and other deposits from bubble caps, trays, downcomers. Circulation method eliminates costly manual cleaning.

2 **HEAT EXCHANGERS.** Oakite offers specialized alkaline and acidic type compounds for removing oil, carbon from shell side; lime scale, rust from tube side. Cleaning is done "in-place".



3 **PAINT STRIPPING.** You can strip paint from storage tank exteriors using your own equipment to apply, recover and recirculate stripper. Oakite provides a complete selection of alkaline and solvent strippers.

4 **SALVAGE.** Oakite has simplified methods to make salvage profitable. They give you a choice of specially compounded materials for cleaning and rust-proofing tools, fittings, valves, chains, pumps, etc.

ON-THE-SPOT SERVICE. Whenever you have a ticklish problem of cleaning to solve you can get quick on-the-spot advice by reaching for your phone and calling your local Oakite Technical Representative. His services are available at all times. For full particulars drop a line to Petroleum Service Division of Oakite Products, Inc., 52E Rector Street, New York 6, New York.

SPECIALIZED INDUSTRIAL CLEANING

OAKITE

MATERIALS • METHODS • SERVICE

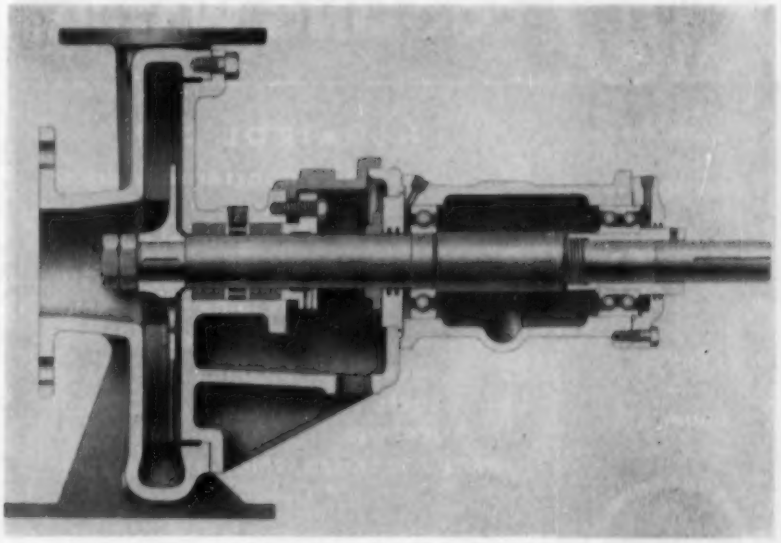
Technical Service Representatives in Principal Cities of U. S. and Canada

OAKITE PRODUCTS, INC.—General Office: 19 Rector St., New York 6, N. Y.

What's New In Equipment . . .

From This Pump:

Triple Bearing Protection



Byron Jackson Company have just announced the addition of a new line of pumps. Called BJ chemical pumps, they were specifically engineered for handling acids and other corrosive chemicals. Four basic pump sizes, available in various motor and impeller combinations, cover a capacity range from 20 to 400 gpm. Special corrosion protection qualities of these pumps include:

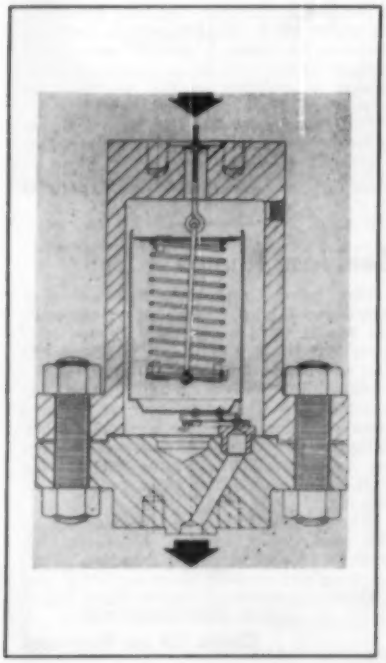
- Corrosion resistant catch basin—an integral part of the pump case.
- Molded synthetic rubber snap-on gland cover to guard against acid spray.
- Triple protection for pump bearings, including a synthetic rubber deflector, stainless steel labyrinth, and grease lubrication.

These new pumps are available in either of two standard materials of construction—alloyed 20 and cast iron.

Additional details, including performance charts, selection table, dimensions and specifications are available now.

This item supplements Byron Jackson Company data on pages 217-220 of The Refinery Catalog, 22nd Edition.

Circle E1 on Postcard



Water Trap

A new forged trap for draining water from compressed air or gas systems at pressures to 3000 psi where no gas losses are permissible has been developed by Armstrong Machine Works. This new trap features a non-collapsible, spring-balanced open float which normally holds the valve closed by the weight of water in the bucket compressing the spring. Entering condensate fills the trap body adding buoyancy to the float. The buoyancy plus the spring compression then overcomes the weight of the water and bucket. This causes the bucket to float—opening the valve and allowing the condensate to discharge. The water seal valve closes before all the water is discharged.

The capacity of this new trap is 2000 pounds per hour at 2000 psi. All working parts are of stainless steel and the body and cap are ASTMF-5 chrome moly steel. Complete engineering details are available on request.

This item supplements Armstrong Machine Works data on page 153 of The Refinery Catalog, 22nd Edition.

Circle E2 on Postcard

End Wrench

A new Toledo end wrench has been added to the line of heavy duty pipe wrenches of the Toledo Pipe Threading

ALGATROL SQ

SLIME CONTROL IN COOLING WATER

Effective
★
Inexpensive
★
Used Easily
★
Safe
★
Stable
★
Longer Life

ALGATROL SQ

1. . . a modified quarternary ammonium salt
2. . . effective in presence of oil
3. . . toxic to both algae and bacteria
4. . . not dangerous to men or animals
5. . . non-volatile — less required
6. . . usual dose: 60 ppm. once a week
7. . . costs less than 1c/1000 gal. makeup

WRITE TODAY REGARDING YOUR WATER PROBLEMS

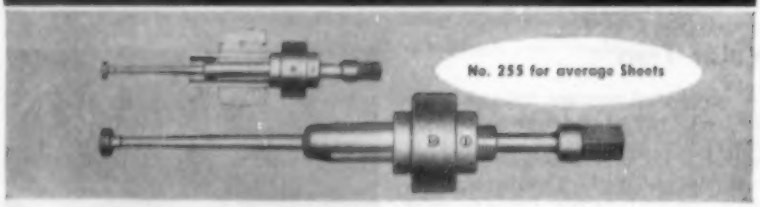
AQUATROL

INCORPORATED

P O BOX 12345 HOUSTON, TEXAS

IDEAL

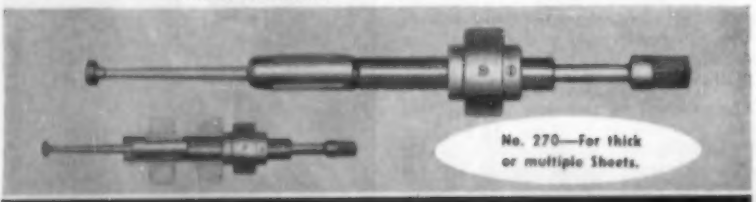
WIEDEKE Precision-Built Tube Expanders



Ball Bearing Adjustable Thrust Collar Tube Expanders are made for Tubes ¼" diameter and larger.
Recommended for use with any Controlled Rolling Motor for uniform expansion of Tubes.

See your Dealer or write us for Bulletin.

For Rolling—Heat Exchanger, Condenser and other Heat-Transfer Tubes.



THE GUSTAV WIEDEKE COMPANY

DAYTON 1, OHIO

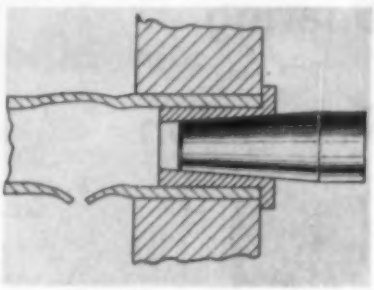
New Equipment . . .

Machine Company. The new wrench is designed with an off-set handle to permit easy use on pipe and coils or against flat surfaces. It is made especially for rugged duty and hard, tough work.

Features of the new wrench include: a new type single spring that will not hang up on small sizes and assures quicker and easier setting of jaws; an easy action nut; improved sure grip handle design; positive hook action; handy pipe scale on hook jaw. These new wrenches are available in 8-inch, 10-inch, 14-inch, and 18-inch sizes.

Complete details are available now. Simply . . .

Circle E3 on Postcard



Sealing Plug

The LaGonda division of The Elliott Company has recently introduced a plug for sealing off leaky condenser tubes. The Elliott tube plug consists of two pieces: a brass bushing with collar, which is a close fit in the tube (its size must be specified as the tube inside diameter at the expanded section), and a steel plug, made with a slight taper to fit the inside taper of the bushing. Because the outside of the bushing is parallel to the tube and tube sheet, the expansion of the bushing when the plug is driven in makes a tight fit and avoids damage to the tube sheet. Complete information is available on this new product now.

This item supplements The Elliott Company data on pages 361-368 of The Refinery Catalog, 22nd Edition.

Circle E4 on Postcard

Seal-less Pumps

Chempump Corporation has announced new 5 and 7½ hp. chempumps. Designated the Model CHS series, these pumps offer users leak proof pumping at heads to 195 feet and capacities up to 300 gpm.

As with other chempump designs, the pump fluid is allowed to enter the enclosed rotor chamber, providing automatic lubrication of the bearings. Rotor and impeller are an integral unit and the only moving part. The pumps are guaranteed not to leak.

The model CHS series is available in cast iron, stainless steel, Monel or Carpenter-20 construction as standard. Temperature and pressure limits are 450 F. and 150 psi with standard models. Much higher limits are possible with special models.

Circle E5 on Postcard

HUNDREDS OF "HOT TAPS" LIKE THIS . . . *without shutdown*

Dozens of Refineries Have proved WmSON-HILLCO Tapping Machines for making connections to . . .

- HIGH TEMPERATURE STEAM LINES
- STORAGE TANKS (BIG-INCH TAPS)
- HIGH PRESSURE GASOLINE AND UTILITY LINES
- CEMENT-LINED AND TRANSITE PIPE
- PRESSURE VESSELS

. . . all without shutdown or leakage

MAXIMUM RATING
700° F @ 700 PSI
and
1,440 PSI @ 100° F.
(CHECK EACH MODEL)

PURCHASE PRICE INCLUDES services of field representative to help in proper use of each new machine

4 Sizes of **WmSON HILLCO** Tapping Machines to Choose From

MODEL 100	MODEL 300	MODEL 660*	MODEL 1200
TAPS TO 2"	TAPS TO 4"	PIPE TAPS TO 14" TANK TAPS TO 16"	PIPE TAPS TO 24" TANK TAPS TO 30"
Hand Operated	Hand or Power Operated	Power Operated	Power Operated
800° F. @ 600# or 1200# @ 100° F.	400° F. @ 200# or 100# @ 100° F	700° F. @ 700# or 1,440 # @ 100° F	500° F. @ 500# or 1200# @ 100° F.

* Model 660 has superseded Model 600 (shown above)
RENTAL-PURCHASE option applicable to models 1200 and 660

T. D. Williamson, Inc.
P O BOX 4038 TULSA 9 OKLAHOMA

REPRESENTATIVES Houston • Pittsburgh • Kenilworth, N. J • Amarillo • Casper • Provo, Utah • Los Angeles • Oakland Baton Rouge • Edmonton • London, Ontario • Calgary • Buenos Aires • Durban, Natal, South Africa

America's Finest

"PETRO" A.A.R.
"PETRO" SOCKET WELD
C. M. & CO. ORIFICE
"PETRO" 304-316
"MARK" A.A.R.
ORIFICE 304 DUAL
"HANDLE-BAR"
"HANDLE-BAR" O RING
"PETRO" 304 DUAL
CHECK VALVES

FORGED STEEL UNIONS, FORGED STAINLESS STEEL UNIONS and UNION CHECK VALVES.

completely illustrated, described and priced in our new Catalog Number 55.

A Letterhead with your signature is all that's necessary to receive your free copy of this comprehensive Union Catalog.

Clayton Mark & Company
1900 DEMPSTER STREET · EVANSTON, ILLINOIS · U.S.A.

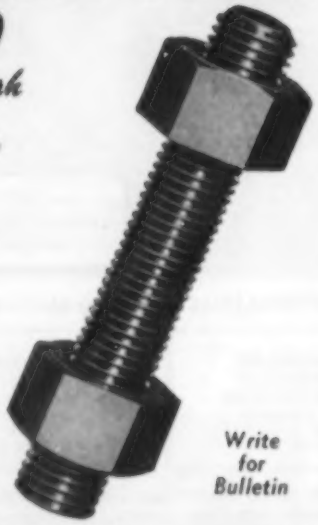
ALLOY STEEL BOLT STUDS

CENTERLESS GROUND

to Provide Smoothest Finish

At No Extra Cost . . .

- Made from heat-treated bars—(A.S.T.M. A193 Grade B-7).
- Threads *centerless-ground* to provide smooth finish unobtainable with most other production methods.
- Finish of KILBOURN ground threads greatly reduces seizing during assembly or disassembly.
- Widely used by oil refineries, chemical plants, power plants, pipe-line installations.



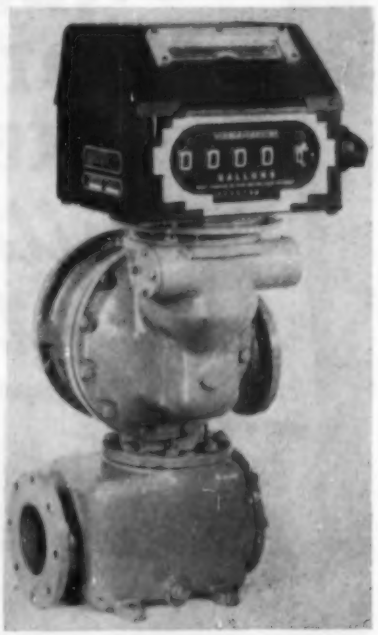
Write for Bulletin

KILBOURN® Engineering Company, Inc.

5102 N. 35th St., Milwaukee 9, Wis.

STUDS · THREADED BARS · STILL SCREWS · STAINLESS STUDS AND NUTS

New Equipment . . .



Stainless Steel Meters

A new series of stainless steel Rotocycle motors designed especially to handle corrosive liquids has been introduced by the Meter and Valve division of Rockwell Manufacturing Company.

The new series of meters includes 2-inch, 100 gpm and 3-inch, 200 gpm, both plant models and 2-inch pipe line models.

Among the many features of this new series of meters are:

- All wedded meter parts made of type 316 stainless steel.
- Hard carbon bushings.
- Stainless steel ball bearings.
- Optional meter-strainer arrangements.
- New style temperature compensator.
- New vapor seal and adapter.

Complete details are available on this new series now.

This item supplements Rockwell Manufacturing Company data on pages 633-640 of The Refinery Catalog, 22nd Edition.

Circle E6 on Postcard

Sling Bridle

Newman Manufacturing and Sales Company has field tested and is now introduc-

PSC
BIG NAME IN
BUBBLE CAPS
300 STANDARD STYLES OF
BUBBLE CAPS & RISERS FURNISHED
without die cost
SEND FOR CATALOG 54
Contains complete engineering data on each of what, we believe, is the largest available choice of alloy bubble caps. Also drawings for use in determining methods of tray assembly. PSC caps are fabricated in any metal to meet your specific requirements.
THE
PRESSED STEEL
COMPANY
WILKES-BARRE, PENNA.
Offices in Key Cities

For more data on advertised products, use Readers' Service Cards, last page.

Below Right: Three of the six Frick refrigerating machines in service at Big Springs, Texas.

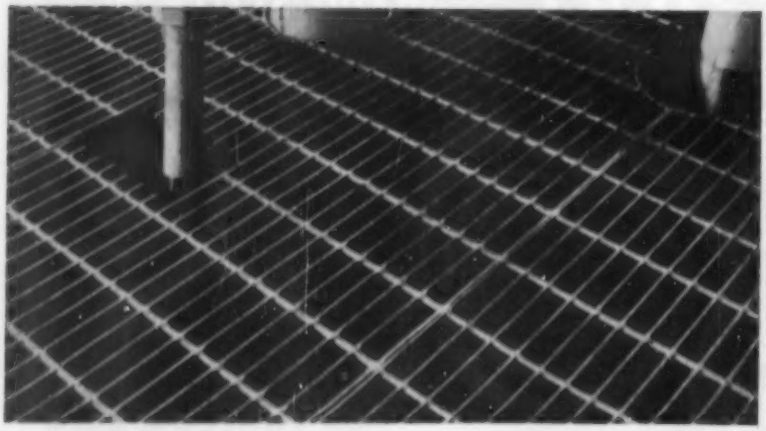
A New Phillips Product
A New Application of FRICK Refrigeration

Phillips Chemical Company's new plant near Big Spring, Texas, is the first in the country to produce 98% pure para-xylene (used in the manufacture of a synthetic fiber) in commercial quantities.

The new, revolutionary process, patented by Phillips, involves continuous fractional crystallization. The heart of the system is a Frick "cascade" low-temperature refrigerating plant that FREEZES OUT para-xylene crystals.

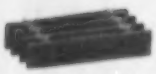
Whether your process is in the idea, development or production stage—if it involves refrigeration or air conditioning, get in touch with your nearest Frick representative, or write directly to . . . . .

DEPENDABLE REFRIGERATION SINCE 1882
FRICK CO.
WAYNESBORO, PENNA. U.S.A.



Gary WELDED GRATING
Tailor Made to Your Specs

Save installation time and money by having Gary factory-fabricate your open steel flooring needs. For complete description of Gary Gratings, write for Catalog No. PR-15.



FREE SAMPLE
We'll send this handy paper weight if you request it on your company stationery.

Standard Steel Spring Division
ROCKWELL SPRING AND AXLE CO.
4011 East Seventh Avenue • Gary, Indiana

New Equipment . . .

ing to the refining, natural gasoline and petrochemical industries the Newco sling bridle. This device is designed to convert, in a few seconds, a conventional sling to a 2-leg bridle sling and, at the same time, eliminate the necessity of a pearlink with two costly eye splices.

The tapered groove of the bridle is designed to firmly grip the sling so that there can be no load slippage even when the load is unbalanced. The legs of the bridle sling can quickly and easily be adjusted or equalized for different loads.

Complete details are available on this new sling bridle now. Simply . . .

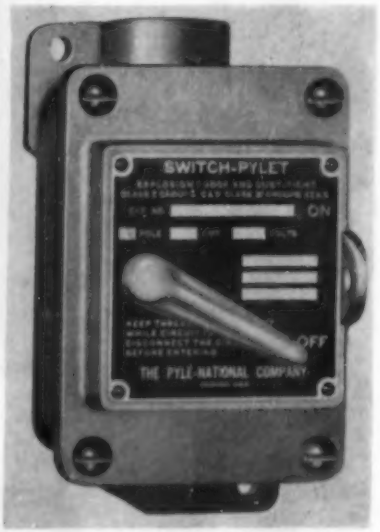
Circle E7 on Postcard

Motor Insulation

A completely new coil insulation with 50 percent longer life than conventional systems has now become available on General Electric induction motors of 100 to 3000 hp. rating. Called Polyex, the new insulation increases dielectric strength by 50 percent and mechanical strength by 600 percent. The insulation utilizes Mylar, Dacron, and synthetic hydrocarbon resins. This material is highly resistant to contaminates as shown by salt water immersion tests. Complete details on Polyex insulation are available now.

This item supplements General Electric Company data on pages 442-443 of The Refinery Catalog, 22nd Edition.

Circle E8 on Postcard

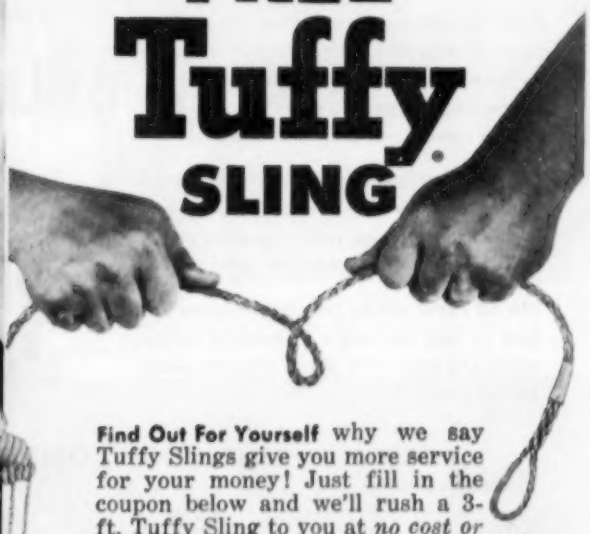


Explosion Proof Breakers

The Pyle-National Company is announcing the manufacture of a new line of circuit breakers and motor starting switches for hazardous locations. Called Pylets, these new items augment the company's fast growing line of explosion proof and dust tight electrical fittings. They are designed for Class I, groups C and D; Class II, groups

TEST IT TO DESTRUCTION IF YOU CAN!

FREE Tuffy SLING



Find Out For Yourself why we say Tuffy Slings give you more service for your money! Just fill in the coupon below and we'll rush a 3-ft. Tuffy Sling to you at *no cost or obligation.*

Then Prove Tuffy's Toughness with any test you want to make! Loop it, knot it, kink it, jerk it—we won't be worried, even if you test your free Tuffy Sling on weights up to *twice* the rated working load!

You'll Find The Exclusive, patented braided-wire fabric construction takes strains and jolts that soon snap ordinary rope slings! It's the unique machine braided, 9-part construction that helps your Tuffy Sling resist kinking—and if you *can* kink it, you straighten it out in minutes *without material damage!*

Get Your Free Tuffy Sling and discover why more and more people are switching to Tuffy every year!

Tuffy HOIST LINE

The Hoist Line That Matches Tuffy Slings in strength and wearability—that's *Tuffy* Hoist Line! Absorbs load shocks smoothly, because it's designed *only* for hoisting . . . passes safety checks weeks after ordinary ropes would have been thrown away!

Ordering Is Easy! No complicated specifications—just state length, diameter and the name, "Tuffy Hoist Line." Reeve your crane with Tuffy and see the difference!

Your Tuffy Distributor Will Help You Keep Your Inventory Down!

He's Happy To Stock Ahead of your needs . . . wants to work closely with you to assure the best possible service. Just give him a rough idea of your future requirements and backed up by his nearby Union Wire Mill depot, he will keep a full stock to draw on against your needs. Get together with him—*soon.*

union Wire Rope corp.

Specialists in High Carbon Wire, Wire Rope and Braided Wire Fabric

TEAR OFF AND MAIL COUPON *NOW!*

Union Wire Rope Corporation
2284 Manchester Ave., Kansas City 26, Mo.

At no cost or obligation to me, please rush the material I have checked:

- ☐ FREE 3-Ft. Tuffy Sling!
- ☐ FREE Sling Handbook and Rigger's Manual, Featuring 12 Tuffy Factory-Fitted Types!
- ☐ Name and Address of Tuffy Distributor Nearest Me!

FIRM NAME _____

BY _____ TITLE _____

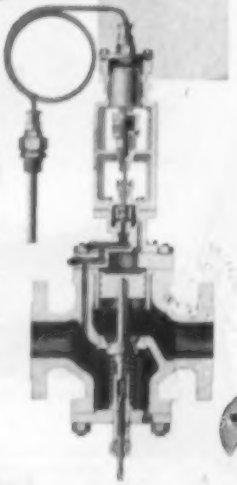
ADDRESS _____

CITY _____ ZONE _____ STATE _____

FOR CONTROLLING TEMPERATURE OF LIQUIDS OR GASES

TEMPERATURE REGULATORS

FOSTER TYPE T



Foster manufactures a complete line of temperature regulators for all types of service — for hot water storage heaters, fuel oil heaters, pasteurizers, ovens, driers, cookers and other process heating and cooling equipment.

They are available in single or double-seated construction; direct or reverse acting; in combination with pressure reducing valves; and in proper materials for the type of service.

Like all Foster valves, they are designed and built for long life with a minimum of maintenance, and are easy to service when necessary. Ask for Bulletin T-101.

75 YEARS OF EXPERIENCE

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE — UNION, N. J.

AUTOMATIC VALVES • SAFETY VALVES • FLOW TUBES

Member of a Great Pump Family

There is a PUMP by Aurora for every pump job.
TYPE-OD
Aurora Horizontally Split-Case, Double Suction, Single Stage Centrifugal Pump.
For general water supply for municipalities, industries, office buildings, institutions—also—for handling liquids, chemical solutions, oils etc., in a wide variety of industries. Write for Bulletin 105-M for further details.

DISTRIBUTORS IN PRINCIPAL CITIES

AURORA PUMP DIVISION

THE NEW YORK AIR BRAKE COMPANY

84 LOUCKS STREET — AURORA • ILLINOIS

New Equipment . . .

E, F and G; and Class III. With ferrous alloy bodies and aluminum alloy covers, Pylets are available in single or two gang types with dead end or through feed hub arrangement. They are available in ½-, ¾-, and 1-inch sizes and are rated as follows:

- Circuit breakers up to 30 amp., 120 volts AC.
- Motor starters up to 1 hp.
- The manual motor starting switches are available with or without overload protection and interchangeable heater units. Complete details on this new line of explosion proof switch gear are available now.

This item supplements The Pyle-National Company data on pages 758-759 of The Refinery Catalog, 22nd Edition.

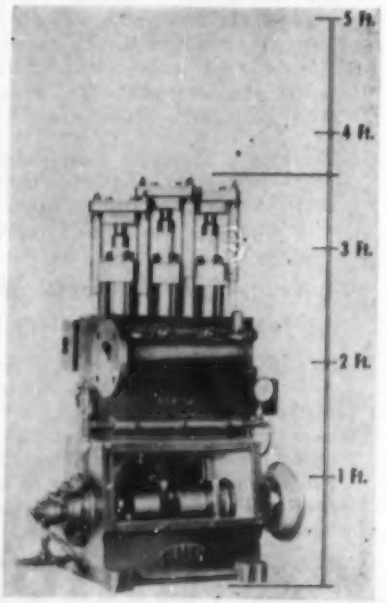
Circle E9 on Postcard

LPG Hose

A new hose for handling butane-propane has been developed by the Republic Rubber division of Lee Rubber and Tire Corporation. Called Wiretex, this new LGP hose is reinforced with a single wire braid rather than fabricated braids used on conventional hoses. The use of wire braid makes the hose light in weight as well as very strong and extremely flexible.

Wiretex LGP hose is available in lengths up to 60 feet and a full range of sizes from ½ inch to 2 inches inclusive. It is designed to withstand a maximum pressure of 350 psi. For complete details on this new product, simply . . .

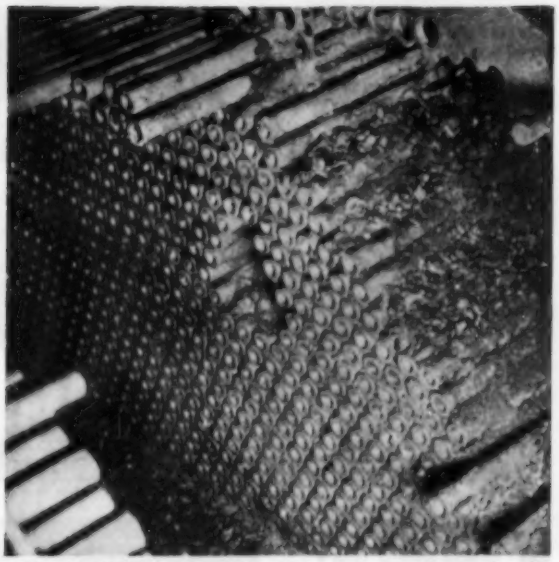
Circle E10 on Postcard



Triplex Pump

The Aldrich Pump Company has developed a new direct flow triplex pump and

POLYRAD STOPS THIS



LOST EQUIPMENT—Cross-section view of a condenser bundle knocked out of service by corrosive attack. Polyrad can help prevent such loss.

LOST TIME—This fouled condenser bundle also cost money to clean. Polyrad's detergent action prevents the formation of organic and inorganic deposits, permits their removal in fluid stream.

There's no longer any reason for frequently cleaning or replacing corroded condenser bundles. Now, through Polyrad's chemical control of fouling and corrosion, this common cause of increased operating costs can be eliminated.

A filming amine inhibitor, Polyrad forms a protective molecular shield that controls the corrosive action of organic and inorganic acids. Throughout the refinery, Polyrad helps maintain throughput, increases heat transfer, reduces metal loss, and cuts down time for maintenance. Fouling is prevented by Polyrad's detergent action, which loosens iron sulfide and other scales to permit their removal in the fluid stream.

Polyrad is readily available from stocks maintained throughout the nation. A Hercules technical representative will be glad to help you evaluate what Polyrad can do for you under your specific operating conditions. For additional data, write Hercules.

Naval Stores Department

HERCULES POWDER COMPANY

976 Market St., Wilmington 99, Del.

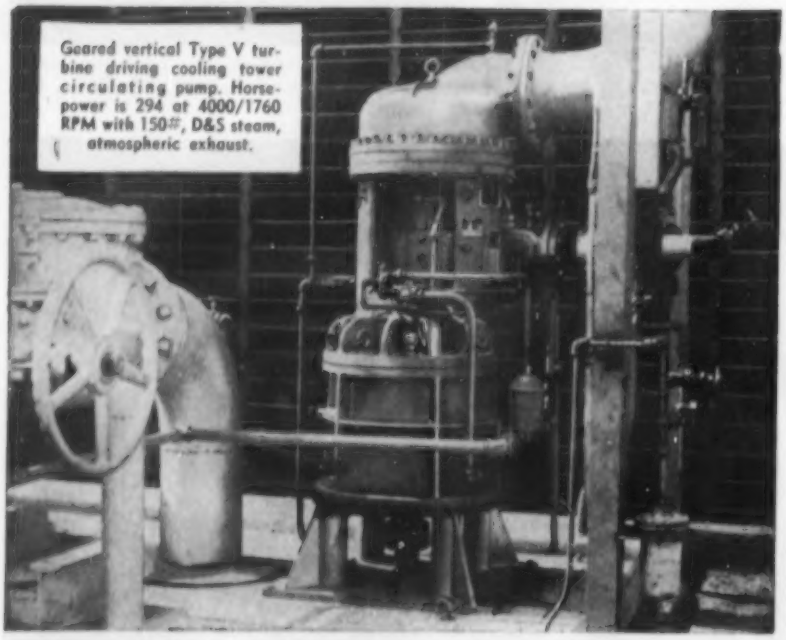
POLYRAD®

FILMING AMINE INHIBITOR

NASA-7

For more data on advertised products, use Readers' Service Cards, last page.

Murray Turbines



Geared vertical Type V turbine driving cooling tower circulating pump. Horsepower is 294 at 4000/1760 RPM with 150#, D&S steam, atmospheric exhaust.

● Murray Vertical V turbines, both geared and direct-connected, are being used more and more for driving vertical pumps of all types. The Murray Vertical V turbine is designed from top to bottom as a vertical turbine, not just a horizontal turbine, "upended." The Murray Vertical is especially constructed and arranged for vertical mounting.

Murray vertical turbines can be furnished for steam pressures up to 600#, 750° F. TT. and back pressures as high as 100# and can carry most normal thrust loads imposed by vertical pumps.

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

New Equipment . . .

is now making it available to the refining, natural gasoline and petrochemical industries. Called "Powr-pac," this new 2½-inch stroke, 25 hp. pump embraces the direct flow fluid-end principle as well as all of the well known Aldrich construction features.

One outstanding feature of this new pump is the sectionalized fluid-end design. Individual fluid-end sections are easily replaced at a fraction of the cost of the entire fluid-end. Working barrels can be furnished in carbon steel, aluminum, bronze, stainless steel or cast alloy. Plungers are available in heat treated carbon steel, stainless steel, solid porcelain or bronze. Valve seats are available in aluminum, bronze, stainless or hard face steel, and valves are available in aluminum, bronze, insurok, stainless steel or nylon.

This new pump is available in plunger diameters from 2½-inch to 11/32-inch for pressures from 390 psi to 20,700 psi with displacements from 109.6 gpm to 2.08 gpm.

Complete engineering information is available on this new line of pumps now. Simply . . .

Circle E11 on Postcard

Discharge Silencer

A new type of silencer, designed for use on the intake and discharge centrifugal blowers where length is a limiting factor, has been announced by Burgess-Manning Company.

Known as the ACA series, this snubber is an absorption type silencer. Air flow is channeled through an annular passage which is lined with acoustically transparent tubes, backed up with deep layers of highly efficient sound absorbing material.

The silencer is an outgrowth of the recently announced LCA series and is offered as an alternate where diameter is not a problem but length must be kept to a minimum. This series of silencers is designed to handle relatively moisture free air up to 200 F. but can be used for considerably higher temperatures with the use of special sound absorbing materials. For complete details, simply . . .

Circle E12 on Postcard

Two-Wire Thermocouple

Minneapolis-Honeywell Regulator Company has just released information on a new two-wire thermocouple which is encased in stainless steel tubing. Use of this protecting tube is expected to double the life of the thermocouple.

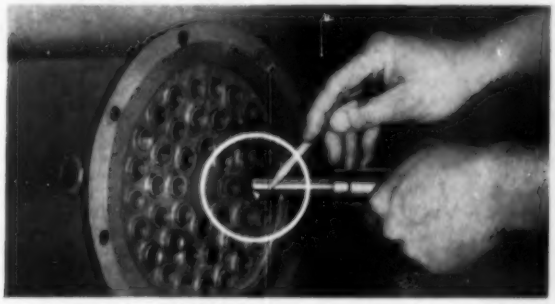
Two types of terminal heads are available: an open head assembly or a screw-cover head. Fiberglass insulation permits greater application flexibility than is possible with the ceramic-insulated pencil type models. Lengths of the thermocouples range from 6 inches to 60 inches. Lengths of 35 feet are availble on a special basis.

Accuracy of the new device is rated at plus or minus 5 F. over a range of 0 F. to 1000 F.

This item supplements Minneapolis-Hon-

See what WILSON's done with the TUBE CUTTER!

This new Wilson Tube Cutter is making a big hit. Simple in design . . . very short . . . can be chucked into any electric or air drill . . . and the cutter bits are easily replaceable. Performance? Well, in a test on ¾"–16 gage tubes, the average time was less than 3 seconds apiece, and the cuts were practically burrless. It's a fine tool . . . and reasonably priced, too.



New Wilson Tube Cutter is easy to use and does a fast job. Cutter sizes and shanks available to meet all heat exchanger requirements.

Tube Pilot helps pass tubes through baffles and for sheet when retubing.

Tube Knockout Tools for hand or mechanical use.

DON'T FORGET!

For faster, lower cost tube cleaning
WILSON TUBE CLEANERS
For easier, better rolling of tubes
WILSON TUBE EXPANDERS

Representatives in all principal cities

THOMAS C. WILSON, INC., 21-11 44th Ave., Long Island City 1, N.Y.
Cable Address: "Tubeclean" New York

WILSON TWB35
TUBE CLEANERS • TUBE EXPANDERS

So SIMPLE that "Specials" are Likely to be Standard!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

MAGNETROL, Inc., 2112S. Marshall Blvd., Chicago 23, Illinois

Please send me catalog data and full information on Magnetrol Liquid Level Controls.

Name_____

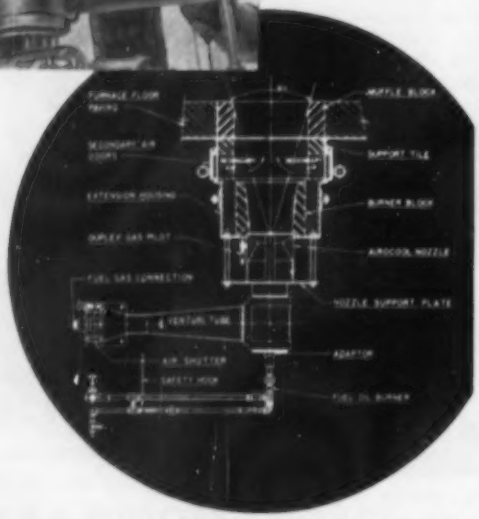
Company_____

Address_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

DESIGNED FOR VERTICALLY FIRED PETROLEUM HEATERS



NATIONAL AIROIL

VERTICAL

Oil-Gas Tandem Combustion Units

many more hours on stream, without forced shutdown

Exclusively for vertical firing, National Airoil VERTICAL C-P Tandem Block Units retain all the features of our regular well-known Tandem Units . . . plus: special pre-cast refractory shapes for easier installation and maintenance; secondary air louvres for positive control of flame pattern; and an all steel duplex detaching gear which enables swift, easy, oil burner removal.

VERTICAL C-P Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Blocks allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

ALL VERTICAL Tandem Units are fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . have a high turn down ratio with steady flames . . . maintain high flame temperatures using either fuel oil or gas. With the C-P TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a shorter time.

"Many, many more hours on stream, without forced shutdown" . . . yes, YOU will realize high profits from YOUR heaters when National Airoil C-P VERTICAL Tandem Units are specified. Our new folder 498 is yours for the asking.

NATIONAL AIROIL BURNER CO., INC.

CHEMICAL-PETROLEUM DIVISION
1254 EAST SEDGLEY AVE., PHILADELPHIA 34, PA.
Southwestern Division: 2512 South Boulevard, Houston 6, Texas

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

New Equipment . . .

eywell Regulator Company data on page 596 of The Refinery Catalog, 21st Edition.

Circle E13 on Postcard

Small Controller

An indicating controller in the low price range for use on simple industrial processes has been designed by The Foxboro Company. Designated the Model 41A Pneumatic Controller, it replaces the earlier Model 41, providing sharp on-off or narrow band proportional control of such variables as temperature, pressure, liquid level and humidity.

When equipped for on-off action, the new controller "snaps" the control valve from fully opened to fully closed when the measurement crosses the control point, handling any process with large capacity-demand ratio and negligible lag.

For a process requiring throttling action, the Model 41A is equipped with a proportional unit adjustable from ¼ of 1 percent up to 25 percent of scale. The unit, a simplified blast feedback proportioning mechanism used in Foxboro's Model 40 Narrow Band Controller, relies on air jet rather than bellows actuated "follow-up" action.

"Left-to-right" indicating scale, with white-on-black numerals and graduations, has been lengthened to five inches, improving readability and accuracy. Internal components, many of them standard Model 40 parts, have been rearranged to simplify routine instrument maintenance. Although case size is only 11¼ x 9 x 4¾ inches, standard Foxboro measuring elements are easily accommodated.

Circle E14 on Postcard

Reader Service Cards → Bring Prompt Replies

HOKE

STAINLESS STEEL CYLINDERS

conform with ICC Regulations

Transport fixed or liquefied gases—even fluids corrosive to ordinary steels—in complete safety. Equally safe for pressure sampling under abnormally high temperatures.

Available for low or high pressure service, in single or double valve types. Sizes from 10 milliliters to 1 gallon. Standard sizes and types normally in stock—special cylinders available on order.

Wide selection of needle and packless valves for use with these cylinders.

Write for complete information

HOKE

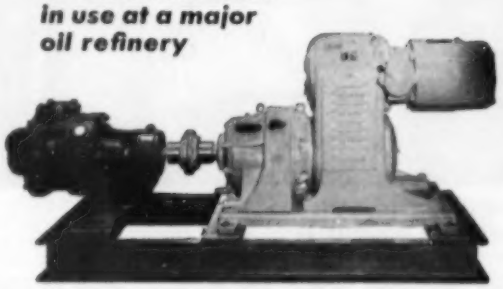
HOKE INCORPORATED

Fluid Control Specialists

167 S. DEAN STREET, ENGLEWOOD, N. J.

An Interesting VIKING Unit

A "straitline" unit in use at a major oil refinery



Viking pumps are recognized leaders in service to the Oil Industry. They're sturdy, compact and dependable. There's a size to fit every requirement.

Southern Engine & Pump Company has been furnishing engineered pumping units to Industry for over 45 years. Complete stocks and competent engineers are ready to help you. We invite your inquiries—

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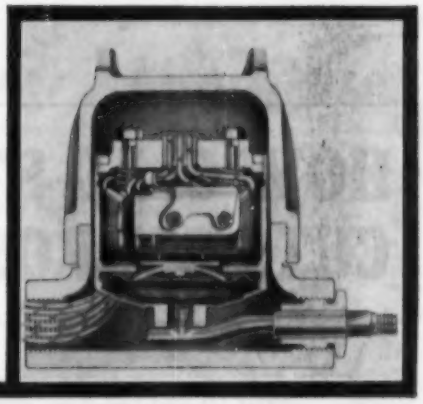

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- **SMALL and COMPACT** *for easy installation*
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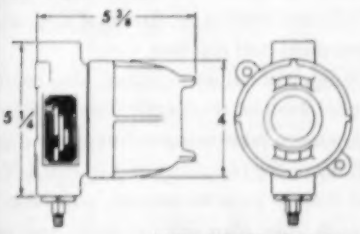

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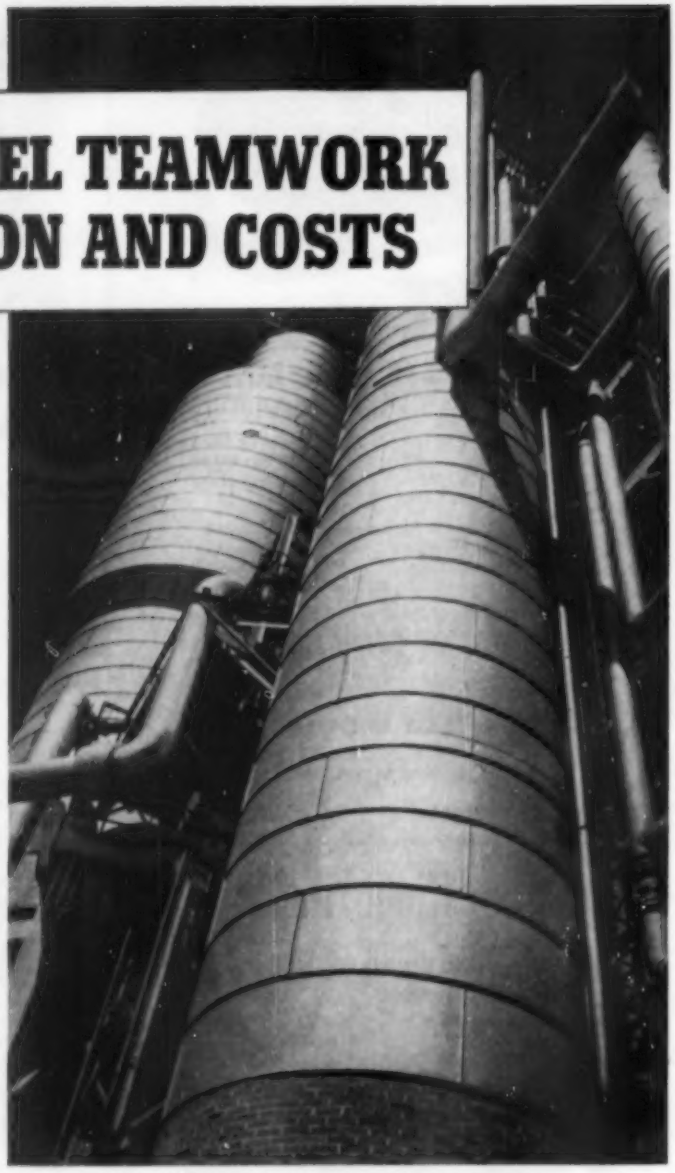
HOW CLAD STEEL TEAMWORK CUTS CORROSION AND COSTS



Two clad steels combine specialized talents to lick corrosion in this 20,000-barrel-per-day refinery unit

Selecting material for this two-stage refinery unit was a double-tough problem. The upper section of the atmospheric tower had to withstand the corrosive action of condensing mineral acids and organic chlorides . . . the lower part had to handle corrosive asphalt crude containing up to 2.50% sulphur concentrations. The vacuum still had to process a lube cut at 750°F. The equipment builder solved the corrosion problem *economically* by teaming up two clad steels: Monel-clad for the upper part and stainless-clad for the lower part of the atmospheric tower, and stainless-clad throughout the vacuum still.

With economical clad steel—a layer of solid high alloy permanently bonded over its entire surface to a low-cost carbon-steel backing plate—there is no possibility of seepage or crevice corrosion . . . no costly maintenance or downtime . . . no equipment failure. In addition, clad steels assure resistance to thermal shock, flexible efficient operation, low first cost and easy economical field erection.

Equipment values like these also result from another kind of teamwork. Sound engineering and modern fabricating techniques can take advantage of the versatility of clad steels. You will find that it pays to consult your fabricators *early* in your planning for tanks and pressure vessels. They can work with your engineers and consultants, translate ideas into the specialized equipment you require.

Ask one of your fabricators to show you the new Lukens clad steel movie, "Equip for New Profits." Here—in full color and sound—are factual accounts of how clad steel equipment brings new economies. The story can suggest new ideas to everyone concerned with production efficiency. Or contact Manager, Marketing Service, Lukens Steel Company, 751 Lukens Building, Coatesville, Pennsylvania.

LUKENS CLAD STEELS

STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEELS AVAILABLE ANYWHERE

What's New in Manufacturers' Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Gas Analyzers

A new 20-page brochure published by Mine Safety Appliances Company gives basic information on the company's line of combustible gas analyzers and alarms. Designed to provide details of how the instruments work, the brochure contains part-by-part descriptions of the components of MSA's analyzers. Actual installations in varied industries are reviewed, and a method of designing a combustible gas alarm system is shown schematically. Instruments to protect against most of the known combustible gases and vapors are described.

Copies of the brochure, number 0703-3, can be obtained promptly. Simply . . .

Circle E15 on Postcard

Cleaning Brochure

Dowell, Inc. has just released a brochure entitled "A Solution to the Problem of Deposits in Piping System." This brochure describes three different methods of chemical pipe cleaning used by Dowell. Also included are some case histories of line cleaning which point out the economic advantages of these methods. Your copy of this brochure is available now. Simply . . .

Circle E16 on Postcard

Line Blinds

The M. N. Aitken Company has issued a new 12-page catalog giving standard dimensions and specifications for a standard series of line blinds made under the trade name of "micro-blanks." Heretofore, no standards have existed on these items and each company made its own drawings and specifications and had the blanks custom-made at considerable extra time and expense. From this new catalog, a standard "micro-blank" can be selected to meet requirements and ordered by code number.

Circle E17 on Postcard

Exchanger Booklet

Precision fabricated heat exchangers for any process industries application involving gas to gas, liquid to liquid, liquid to gas, powdered solid to liquid, high pressures to vacuum, and temperatures from 280 to 1600 F. are described in a new 12-page booklet just published by The M. W. Kellogg Company.

A unique feature of the booklet is a cross sectional diagram presentation of a variety of these heat transfer units. The booklet also shows heat treating facilities at Kellogg, which, incidentally, are capable of handling vessels up to 13 feet in diameter and up to 80 feet in length. Your copy of this booklet is available now. Just . . .

Circle E18 on Postcard

Armored Motor Bulletin

A new full color, 4-page publication describing direct current types MD and MDP 600 series armored motors is available from General Electric Company.

The bulletin provides information on performance and maintenance features of the heavy duty GE motors. Included in the bulletin are horsepower ratings and other mechanical and engineering data. Diagrams and photographs completely illustrate the various applications of these armored motors in industry. Your copy of this bulletin, GEA-4654C, is available now. Simply . . .

Circle E19 on Postcard

N-Cl Bulletin

International Nickel Company has recently published a 28-page basic reference bulletin presenting the many valuable characteristics of modern nickel cast irons and illustrating their broad acceptance throughout industry. Fifty illustrations indicate wide industrial usage in all sizes and shapes. Over 25 tables, charts and photomicrographs show how, through the use of nickel, alone or in combination with other alloying elements, the engineering properties of cast iron can be controlled to meet modern service requirements. These modern alloyed irons with their greatly improved physical and mechanical properties can be produced by any foundry having reasonable control. Your copy of this bulletin is available now. Simply . . .

Circle E20 on Postcard

Floating Roof Brochure

In connection with the latest design Floating Roof, the Hammond tubeseal, Hammond Iron Works has just published bulletin TS. This bulletin describes in great detail the features and operations of their new Tubeseal system which is designed to eliminate all the vapor space in the seal area and thus prevent vapors from forming as well as to provide a tight seal at all times. Answers to the most significant questions related to floating roof operations are included in bulletin TS. Your copy of this bulletin is available now. Just . . .

Circle E21 on Postcard

Analyzer Bulletin

A complete line of combustible gas analyzers and alarms is described in a 20-page brochure recently published by Mine Safety Appliance Company.

Prepared to give details of how these instruments work, the brochure contains part-by-part descriptions of the components of MSA's analyzers. Actual installations in varied industries are fully covered and a method of designing a combustible gas alarm system is shown schematically.

Copies of this brochure, number 0703-3, are available now. Just . . .

Circle E22 on Postcard

Corrosion Bulletin

How to control corrosion with stainless tubing and pipe is the subject of a new 28-page bulletin recently issued by the Alloy Tube division of the Carpenter Steel Company. Illustrated with photographs of parts and applications, the booklet contains corrosion resistance tables, charts, field reports from users, details test results and other similar engineering information. The bulletin covers many types of stainless alloys as well as describing the characteristics and performance of several super-corrosion resistance steels. Helpful information is given on selection and specific alloys suggested for varying conditions. Your copy is available now. Just . . .

Circle E23 on Postcard

Couplings Folder

A new 16-page illustrated folder on malleable pipe couplings and fittings has just been published by Gustin-Bacon Manufacturing Company.

Thirty photographs and many diagrams illustrate this brochure. Complete specifications are given for rolagrip, gruvagrip, and gruvajoint couplings. Your copy is available now. Simply . . .

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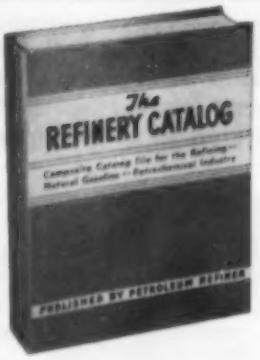

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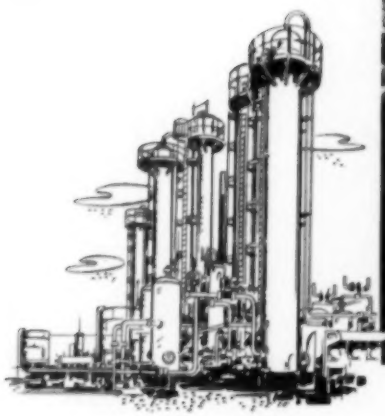

• Just how the Petroleum Industry is going to meet the requirement of doubling its refining capacity in the next twenty years is beyond our calculation.

What we do know is that it will call for Wyatt's shops to keep moving pressure vessels into refining plants the country over, as this one is going into service in the Lake Charles plant of Cities Service Refining Corporation.

Wyatt's
HOUSTON-DALLAS-NEW YORK-TULSA

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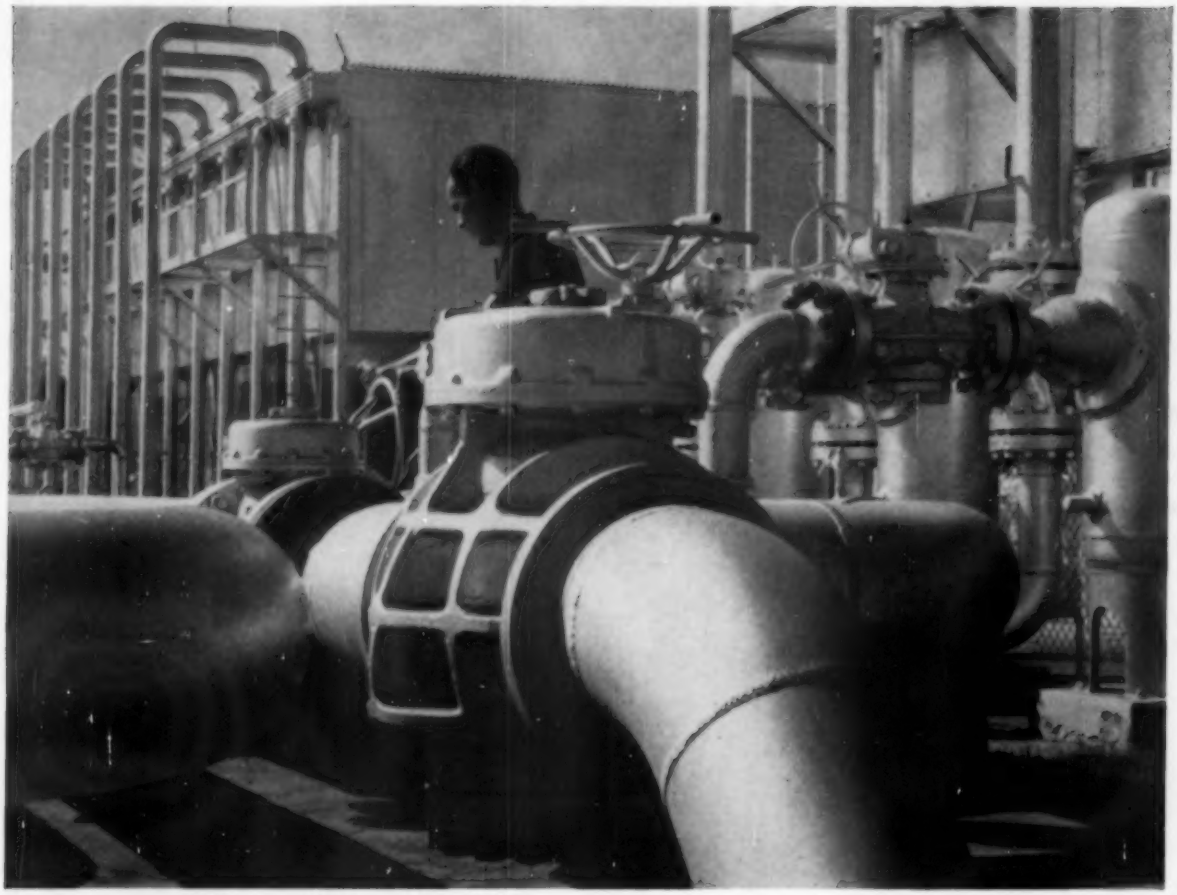

Positive Shut-Off
Fast, Smooth Closure
Low Maintenance

Rockwell-Nordstrom Valves

For forty years, field experience has proven that you can't buy a better valve than Rockwell-Nordstrom. Pressurized lubricant sealing assures positive shut-off because the seal doesn't depend upon uncertain metal-to-metal closure. The *tapered* plug seats perfectly, and can be hydraulically jacked for *instant* operation. And facts and figures in hundreds of refineries, gasoline plants and petrochemical plants prove that lubrication saves money by cutting repair, replacement and down time costs.

Wrench and gear operation is fast and smooth with Nordstroms because the plug requires only a quarter-turn for closure and it glides on the lubricant film. Their speed and ease of operation make them ideal for automation or remote power operation, too.

. . .

Rockwell-Nordstrom is *the original and only complete line* of lubricated plug valves. There is a size, pressure-temperature rating and pattern to fit your needs. Write for more information today: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

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